AN INVESTIGATION OF GREEN SPACE IN A DEVELOPING COUNTRY CITY: THE FEASIBILITY OF CREATING A NETWORK OF SUCH SPACES

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ABSTRACT: In developing countries a big issue for urban development is the growth in infrastructure in response to economic and population demands. Such development causes cities to expand and occupy the suburbs, turning them into more built up areas. The impacts of such urban growth are immediately observable in the reduction of green areas and environmental quality, and diminishing contact with the natural environment. This study will focus on green spaces in a city in a developing country to consider the effect of this urbanization.

In response to urban growth in developed countries attempts have been made to link together green spaces into a form of networks. These networks are intended to conserve the function of natural areas in towns and cities while still accommodating development. The greenway or green network and ecological network are two successful approaches developed in America and Europe. This study assesses the green spaces in Makassar, an Indonesia city, to see possibility of implementing such concepts.

The study begins by redefining spaces into a typology, then assessing the spaces through three stages. The first stage is biodiversity assessment. The Rapid Biodiversity Assessment, adapted from a study in the UK, is used to assess plant biodiversity as an indicator of the quality of green spaces in urban areas. This method was adjusted and simplified to reflect the limitation in resources and time. The second stage was assessment of spaces based on a target species, in this case urban birds. The third stage combines the biodiversity score with consideration of space size and ownership. This stage produced different classes of spaces.

These stages produced three different maps which were then overlaid to find the best quality green spaces termed 'the most preferred spaces'. The next step was to see whether these spaces could be linked up in a network and to determine what sort of network could be achieved. In this part of the analysis spaces are grouped into main patches and scattered small patches, termed stepping stones. With this approach the potential connectivity can be observed visually. This study also acknowledged the significance of areas of ecological quality outside the main city but within the greater urban region and proposed connection of the network of spaces outward towards two natural parks, which could be considered as the main ecological patches.

Having assessed the two main elements of a green space network—patches and corridors—through visual observation of the maps generated by the fieldwork, this study concludes that currently an ecological network is not feasible for the city because of the condition of the green spaces that make up the patches and corridors. Even a greenway along the main river corridor is not currently feasible because the highly valuable natural remnants have been significantly fragmented by cultural activities. Similarly, the road corridors are also not currently in a promising condition. The thesis ends with recommendations for the improvement of these.

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DEFINITION OF TERMS USED IN THE THESIS

All terms presented here are used in this thesis. Their definition is based either on interpretation from one or more sources and modified to reflect the most appropriate use in the thesis context, or from the original source as referenced.

Space: An area which is usually bounded in some way by structures or objects, and that might be reserved for a particular purpose.

Open space: An un-built area whether empty or occupied by assemblages of plants.

Green space: Any feature whether natural or artificial, private or public, as long as it contains natural elements such as plants and grass, which overall provide the experience of contact with nature (See Table 2.1. p 12)

Public green space: Green space owned and managed by a local authority which is provided for public use and access (Minister of Public Works, 2008).

Private/institutional green space: Green space owned by an individual or certain institution for limited users, in the form of house yards, institutional space or corporate space (Minister of Public Works, 2008).

Network: Linkage of spaces within a single system, being either connected through structural or functional connectivity or a combination of both.

Stepping stone: Spread of spaces or patches within reachable range which make it possible to accommodate species movement.

Connectivity: The ease with which organisms and materials can travel between two points.

Green network: Linked spaces that have the qualities of open/green spaces in many forms or have the potential to be so.

Greenway: Ecologically significant corridor with specific functions and values (Fábos, 2004)

Ecological network: A network consisting of a series of ecological patches which are connected by linear corridors or small green spots within reachable range serving as stepping stones. Its function is highly dependent on the nature of the patches and which species they support, either residing permanently or temporarily through species movement and migration (see p 36).

Core area: A main protected area of landscape conservation, nature parks, and for other conservation purposes with possible limited uses such as agriculture, forestry or recreation where public access is regulated (Jongman & Pungetti, 2004).

Buffer zone: An area on or near an edge or constituting an outer boundary which serves as protection where restrictions are imposed upon resource use (Jongman & Pungetti, 2004).

Typology: Classification of spaces based on various assumptions (Table 5.3. p 96) following observation through aerial photographs and on-site fieldwork.

Land-use type: Classification of open and built spaces mainly based on their functional state and official government classification.

Patch: An area within a landscape with a specific use and function which makes it distinct and different from its surroundings (Bentrup, 2008; Forman, 1995).

Corridor: A continuous or disrupted feature in a linear form which differs from the adjacent land on both sides (Forman, 1995).

Biodiversity: A term related to species richness, which has also been viewed from different perspectives depending on the background of those who have an interest in it, causing widespread definitions of biodiversity (Please see Section 6.1. for more explanation).

Target species: A species which is important for its sensitivity, taken as a consideration in analysing urban space for ecological purposes, especially in the context of interaction between people and wildlife in urban settings (Hepcan, Hepcan, Bouwma, Jongman, & Özkan, 2009; Savard, Clergeau, & Mennechez, 2000).

Domin value: A value derived from dominance assumption based on land coverage characteristics, consisting of 10 classes with a range of 0 – 100 percent and obtained through visual observation (See p. 128).

'Eco' patch: a term introduced in this thesis, to refer to spaces with higher potential for their value in being green, having high vascular plant biodiversity, and favourable size and status, hence that have the potential for being ecological patches at some point (See p…. and Table 8.11.).

'Green' patch: a term introduced in this thesis, to refer to spaces which have quality as green and vegetated areas, but which are unlikely candidates for ecological spots because their biodiversity score, size and status are unfavourable (See p…. and Table 8.11.).

Most preferred spaces: a term introduced in this thesis, to refer to spaces which are considered to be the best quality spaces based on filtering using the three main stages in this study, and also the ones to be linked up into a possible network (See Section 9.1.).

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Chapter 1

Introduction

1.1. Background

Human beings and nature are two inseparable components. In addition to the elaboration of the principle in ecology that an organism requires interaction with its environment, the human need for nature is not just physical but also psychological.

More people are now living in urban areas in almost all parts of the world. Although a city is an ecosystem dominated by artificial man-made features rather than natural components this does not imply that human beings have been totally disconnected from their coexistence with nature. Meanwhile, development which results in the environment becoming more urban seems part of human beings expressing themselves as the most powerful and intelligent members of the ecosystem. This occurs at the expense of other creatures, once the 'original inhabitants' of an area which eventually becomes a city.

However, the human need for a natural environment has made people realize the importance of coexisting with nature, and of the need to share space with other beings in a harmonious way. This has led to a change in urban growth and development towards a more environmentally friendly city within the principle of 'back to nature'. This has triggered issues which have led to the emergence of the concept of nature conservation in urban areas going hand in hand with the harmonious development of the city. Towards this end the United States of America (USA) developed the greenway concept and Europe the ecological network to bring nature back into the city in a connected way. Both have been further developed (see Chapter 2) and are known by various terms such as green infrastructure, green networks and habitat networks. However, all aim at an ecology based concept for urban development, although this will have different patterns and adaptations appropriate for local conditions.

As the originators of this concept, many examples of the acceptance and application of these ideas in urban areas are seen in developed countries, especially in cities in Europe and the USA. Developing countries such as China have also started to study and implement this ecology based concept for urban development.

Although there are many precedents in developed countries, it is important to have good knowledge of the potential and specific conditions of a city in a developing country before implementing concepts such as a greenway or ecological network, given the various differences between developed and less developed contexts. This thesis, therefore, provides an overview of efforts to examine the possibility of applying ecological concepts in a city in Indonesia as a developing country in Southeast Asia. Although there are examples of the application of ecological concepts in Asian cities in Japan, China and Singapore, adopting outright the application of the ideas, at least Japan and Singapore, may not be appropriate as they more represent the context of developed countries. There are considerable differences between the socio-cultural and economic circumstances in these two countries and those of Indonesia. Therefore, the study which forms this thesis specifically analyzes what is necessary to assess and determine the feasibility of implementing an ecologically based network concept in a city in Indonesia. The study location is Makassar, a fast growing city in Eastern Indonesia, which is considered typical of cities in Indonesia. As the biggest in South Sulawesi, Makassar is the main urban region. Makassar has been reported as the most urbanized city not only in Sulawesi Island but also in Eastern Indonesia.

This study begins with the steps for evaluating the potential prior to assessing the possible insertion of some type of network of green spaces based on the existing potential of open spaces in the city. The results are intended to be options for optimizing the potential spaces within a network or networks and recommendations for increasing the value of the spaces that exist in terms of their management.

1.2. Thesis chapter outlines

This thesis consists of 11 chapters which are methodologically sequenced to describe all processes of thinking and stages of the research.

Chapter 1 is an introduction which sets the scene, explaining the background to the need to perform the research.

Chapter 2 is an overview of urban spaces and related issues such as urban development and its effects on people and the environment, the ecology of urban areas, general types of urban spaces with their influence on human beings, and efforts to resolve problems related with urban development.

Chapter 3 explains the method behind the research along with the staged steps for performing the assessment and study of the main city of Makassar and the greater urban region. Referring to the background knowledge in Chapter 2, the research questions and objectives are also presented in this chapter.

Chapter 4 provides an overview of the city of Makassar as the study location. The chapter includes a brief history of the city, and describes its geographic and demographic aspects, as well as the general landscape character of the city and spaces within it.

Chapter 5 gives an explanation of how the typology of spaces for the city was developed. Based on the existing spaces and land uses, this study develops a typology by considering several factors and assumptions. Assessment of spaces based on the typology is also performed according to certain prioritized criteria. This chapter also describes how the priorities for the fieldwork were determined.

Chapter 6 explains the biodiversity assessment method in detail, this being the main method of assessing spaces in the city. This chapter also contains a background literature review about biodiversity assessment and how the particular biodiversity assessment method for this research was finally selected.

Chapter 7 presents the results of the biodiversity assessment and scoring of typology-based spaces in the city. The biodiversity of each typology is presented along with additional supporting literature as necessary.

Chapter 8 is the analysis chapter that assesses the quality of spaces in the city. The analysis includes the biodiversity assessment results and classification of the biodiversity scores, consideration of urban species and the ordering of spaces into different classes by considering biodiversity level, space size, and land status and ownership. The analysis results in this chapter are important for the further analysis presented in the next chapter.

Chapter 9 continues the analysis results of Chapter 8 with a procedure for suggesting the most preferred spaces in the city. This chapter also presents an analysis leading to options for connecting spaces in the main city, as well as an analysis of the possibility for forming a network at the larger scale of the greater urban region.

Chapter 10 is a description of the value of the spaces to the city beyond forming them into a network, including the relationship of urban green spaces to demographic aspects. The chapter also provides information and analysis regarding suggestions for improving the quality of spaces in the city.

Chapter 11 draws together the results of the research in relation to the research questions and suggests aspects for research improvement in the future, as well as possible further research in related topics.

Chapter 2

Urban Development and Ecology

This chapter provides an overview of the issues and embedded aspects related to urban spaces as these relate to the general topic of this thesis. These issues have emerged with awareness of the need to create a better urban environment in terms of ecological quality through balancing the economic advantages of the vast advance in urban growth with provision for the natural experiences the psychological welfare of urban dwellers demands. Because this research is formulated within a discussion of green spaces in an urban area it is first important to review the background issues to modern urbanization, as these issues will also be returned to at the end of the thesis when the demographic aspects of green space in Makassar are considered (Chapter 10).

2.1. Urban regions and built areas

A **city** is an urban district with corporate status and powers of self-government which is relatively large and important, hosting a range of population sizes, whereas an **urban region** is a city and its surroundings along with all interactions in between (Richard T.T. Forman, 2008). The definitions of a city and urban region are also based on population, where an area is considered urban when the population is at least 150 people/square km (Niemelä, 1999). A city has physical structure which consists of buildings, infrastructure (e.g. roads, railways), technological infrastructure (e.g. power systems, cell phone networks) and green infrastructure (e.g. parks, green corridors) (Sandstrom, 2008).

In more urban ecological terms, a city could be seen as a site where complex sets of biological and socioeconomic processes occur within a specific natural matrix. Therefore it is made up of naturally driven processes and the activities and dynamics of human beings (Aminzadeh & Khansefid, 2010).

A **built area** is piece of land with structures or buildings which continuously stand in one place as properties or plots (Richard T.T. Forman, 2008). Development leading to an increase in built area is one aspect of urbanization in cities.

The way an urban ecosystem differs from a natural ecosystem mainly relates to human involvement and external influences. While a natural ecosystem is more autotrophic, an urban ecosystem is dependent on external energy and material inputs (Alberti, 2008b). In terms of the content, urban ecosystems host more non-native species which are spread in fragmented patches (M. Ignatieva, Meurk, & Newell, 2000). The man-made surfaces and features within urban ecosystems provide amenity for humans but can also cause unfavorable effects for the natural systems around. Human activities are also significant in their effect on the urban ecosystem.

2.2. Factors related to urban development

Urban change due to development is a phenomenon occurring in almost every part of the world. The dynamic changes are strongly related to anthropological factors including economy, society, culture and technology. In one view, this development in inevitable, and favourable for increasing the quality of people's lives. On the other hand development has implications for the environment. Consequently, the next section provides information on factors related to modern urban development in cities in both the developed and developing world, although the magnitude of each factor could be different for each city.

2.2.1. Urban population

Population growth is a phenomenon found in almost all parts of the world. The Population Reference Bureau (PRB) reported world population grew from 2008 to 2009 by 83 million people. The rate of increase is growing at an unprecedented rate, doubling every forty years (Warren, 1997), or four times in 100 years (Carreiro, 2008). Despite the fact urban areas only cover 3% of the earth's face, 50% of the world's population resides in urbanized spaces (Murray, Mohareb, & Ogbuagu, 2009; Singh, Pandey, & Chaudhry, 2010), amounting for more than 3 billion people in the first decade of the 21st century (Richard T.T. Forman, 2008).

The image of the city as a land of hope for a better life has attracted more people to come into urban areas. The United Nations Population Division reported that cities worldwide accrue about 200,000 additional people a day, equating to 70 million per year (Richard T.T. Forman, 2008). The increasing population especially in urban areas has resulted in pressure being imposed on cities due to life needs and demand for facilities. Again according to the UN, by 2030 more than 60% of the world's population is projected to live in cities (Bolund & Hunhammar, 1999; Carreiro, 2008; Niemelä, 1999), mainly as a consequence of births and immigration, which will exceed deaths and emigration (Richard T.T. Forman, 2008).

As urban dwellers try to fulfil their living needs and find satisfaction, they are inevitably driving cities to become less environmentally friendly sites. Increasing demands for more advanced and modern living activities lead to changes and development for the sake of economic and social needs (J. R. Linehan & Gross, 1998). Consequently, although cities occupy a small proportion in terms of area, they are responsible for 60% to 78% of carbon emissions, 60% of all residential water use and 76% of wood consumption for industries (Murray et al., 2009; Singh et al., 2010).

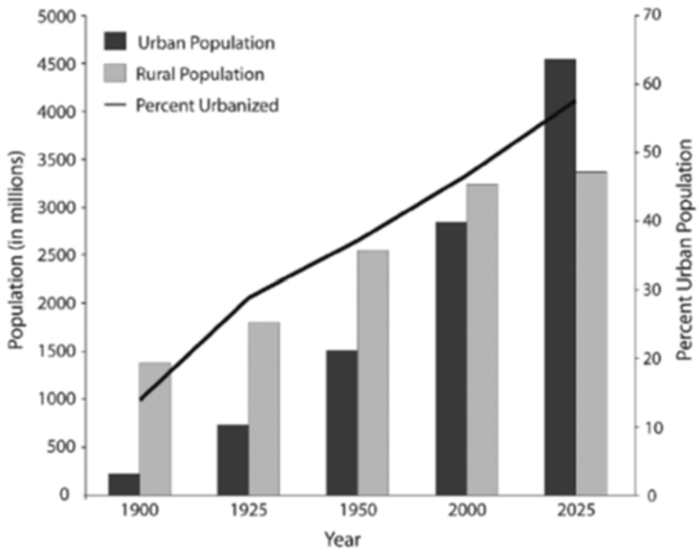

Figure 2.1. Urban and rural populations, actual and estimated,
(Source: Alberti (2008a))

Figure 2.1 shows population growth as one aspect of urbanization. The urban population has significantly increased and is projected to exceed the population in rural areas. The growth trend and current urban condition suggests that in not many years from now there will be great pressures on the environment from cities. Therefore authorities in most places in the world should have appropriate plans to respond to this phenomenon.

According to Warren (Warren, 1997) and as reported by the PRB (Population Reference Bureau, 2009), among world populations developing or less developed countries have a much higher share of global population, so that the fastest population growth will be almost entirely in this developing world. World population growth in the 20th century was dominated (90%) by countries which are classified by the United Nations as less developed countries (Bremner, Haub, Lee, Mather, & Zuehlke, 2009). They comprise all African countries, Asia (excluding Japan), Latin America and the Caribbean, and all Oceania except Australia and New Zealand.

As a developing country, Indonesia contributes to world population with more than 237 million people according to the last census in 2010 (Indonesian Statistic Board, 2012). The fast population growth leads to the prediction the population will reach 300 million in 2032 (ANTARA, 2013). Being the 4th most populous country with a traditional farming culture, this country is now showing population shift with 44% of the population residing in urban areas (United Nations, 2010).

For a large country such as Indonesia, it might be important to see whether the problems that come with urbanization are attributable to the huge population or lie in the way settlement is laid out. For the latter, as people develop the city they tend to increase density, which often squeezes out natural habitats. It is thus important to address how dense urban settlements and natural habitat might co-exist side by side.

2.2.2. Urbanization

The facilities and infrastructure in urban areas make them a magnet for people from the outside (Murakami, Zain, Takeuchi, Tsunekawa, & Yokota, 2005). As a result, for years significant numbers of people have been swarming into cities for various purposes. This has resulted in pressure for expansion due to the need for more housing and other supporting infrastructure. A clear consequence of the upsurge in housing development, as seen in the developing context of Kuala Lumpur for example, is the conversion of green spaces and natural areas to built-up space, where the decline in the open space ratio is directly related to population increase (Teh Tiong, 1994). Kuala Lumpur has the highest population growth rate of 5.0% a year, which has severely degraded the urban environment (Yaakob, Masron, & Masami, 2011).

Urbanization can refer to the growth of a city related to various embedded factors. Some argue urbanization is more relevant to the proportion of the total population living in urban areas and not simply to the growth of cities (Rukmana, 2007). However, population growth is not the single cause of urbanization, as in some more developed cities urbanization also refers to densification of built areas that have spread outward. Demand for things such as gentrification, industrial development and all types of modernization can occur without significant population change (Richard T.T. Forman, 2008). However, urbanisation in developing countries is occurring much faster than in developed countries (Uy & Nakagoshi, 2007).

Despite the lack of knowledge and measured assessment of the effects of urbanisation on the ability of both natural and semi-natural habitats to support biodiversity (Mörtberg, 2009b), urban development has many implications for natural environments within and surrounding the city. The inevitable pressures caused by the activities of urban dwellers and fulfilment of their needs spread out across the city border and affect the urban fringes, often creating continuous development as on-going process of urbanization. This is one factor which could be the cause and also the result of urban population growth. This relates not only to movement towards the city, but also to the expansion of the city towards the suburbs.

This urbanisation process with its complex land use pattern is responsible for habitat loss and fragmentation, puts pressure on and threatens natural remnants (Rob H. G. Jongman, Külvik, & Kristiansen, 2004; Mörtberg, 2009a), causes high demands for use of fossil fuels, materials and resources, and produces enormous quantities of waste and pollution, which are harmful both for people and biodiversity (Sandstrom, 2008). In addition, the establishment of any new artificial green areas often involves use of non-native (exotic) species for their aesthetic value (M. Ignatieva et al., 2000).

2.2.3. Haphazard development

Urban growth is inevitably implicated in many changes and disturbances in the area where development takes place. Various urban developments related to land use for the sake of the economic and dynamic prosperity of the urban population leave less opportunity for other purposes. Accordingly, there are pressures within urban areas for more open space (Barbosa et al., 2007). When development is out of balance with the intention to share spaces for environmental reasons, problems will probably be encountered.

Most development in urban areas in Indonesia is mainly focused on the physical aspects, especially provision of infrastructure. Many major cities in Indonesia have witnessed the effects of urban development which converts open spaces into buildings, roads, residences and other hard structures. This failure to establish integrated urban development plans which take account of ecology and environmental sustainability is resulting in increasing problems within urban areas (Goldblum & Wong, 2000). Additionally, the inharmonious relationship between people and nature has caused urban areas in Indonesia to improve economically but deteriorate ecologically. Additionally, existing open spaces and urban green areas are less well maintained and poorly nurtured because they are often under threat of conversion. Disturbances in urban ecology will result in deterioration of urban environmental quality, apparent in air pollution, microclimatic shifts, fresh water deficiencies, and decrease in urban visual quality.

Haphazard development in urban areas will eventually have a negative effect on nature through the loss of natural areas, fragmentation of open and green spaces, degradation of water resources, and the loss or deterioration of ‘free’ natural and environmental services (Benedict & McMahon, 2002).

Furthermore, sprawling development is responsible for the fragmentation of wildlife habitat, restricting travel by animals, which is normally required for feeding and mating, beyond their immediate habitat. Human activities disrupt wildlife habitat, worsening the pressures on animals. There are also unfavorable economic consequences of sprawling developments, mainly related to their operation and maintenance cost, which have reached US$ 400 annually as reported by Rutgers University (Benedict & Mahon, 2006, pp. 9-10).

2.2.4. Issues in developing cities

The issue of green space in the context of a developing country has to be looked at along with other concerns such as poverty, illiteracy, unemployment and poor health standards. For many developing areas these issues have distracted the authorities and political powers from concern about ecosystem quality deterioration.

The human need for access to green space is not exclusive to developing cities, as even cities in developed countries can suffer from insufficient access. A study in Sheffield, UK reveals up to 72% of Sheffield households are not within the recommended distance for green space access (Barbosa et al., 2007).

Developing countries in general would see financial matters as a limiting factor for the development of green spaces in their cities, with these generally being ranked behind other more economically promising priorities (Benedict & Mahon, 2006; Gregory Mc Pherson, 1992). However, cities in more developed countries can also suffer decline in their green spaces because of funding factors and budget constraints (Pauleit, 2003). Therefore it seems important to find creative ways of incorporating and managing green spaces in urban areas under circumstances where the budget is limited.

Additionally, concern for a better and more comprehensive support for the provision and maintenance of urban green space is not specific to a city like Makassar. There is also need for a country like the UK to learn from exemplary cities in terms of better maintenance of urban green space (Carmona, Magalhães, Blum, & Hopkins, 2004). It seems that some aspects of lack in urban green space management in the UK are also relevant to Makassar, although the magnitude in the latter might be greater due to budget and other resources differences.

2.3. Urban ecology

In any place where interaction occurs inter species, between species, and between species and their physical environment, the system created is observable and assessable through the science of ecology. Likewise, cities and urban areas are where a complex system of interactions occur involving human beings as the dominant species (Alberti, 2008a). The impact of human domination ranges from low in less urbanized areas to high in highly urbanized areas.

The term ecology has been used to denote the interactions between an organism and its environment. When the term landscape is defined as mosaic of land within a certain range of distance (Dramstad, Olson, & Forman, 1996), then landscape ecology in this sense is the interactions of all ecosystem components within the range of the confined landscape. Apart from great human influence, an urban ecosystem is also different from rural (natural) ones in terms of climate, soil, habitats, ground and running water, pollution level, species composition and dynamics of plants and animals (Rebele, 1994).

Discussion of ecology in a city or urban context needs to set out the difference between ecology *in* the city and ecology *of* the city. Ecology in the city considers science in terms of the ecology of both animals and plants found in urban areas, along with all biophysical processes that have influence on them. Ecology of the city starts with an understanding of the city as a built environment in which all components interact with it, characterized by human activities which are dependent on and supported by natural as well as man-made functions and processes (Pickett et al., 2001). However, the general basic definition of ecology with more consideration for human impact is also acceptable (Niemelä, 1999).

Ecology in urban areas is significantly affected by the existence of spaces which have provision for natural components to persist. They occur in many forms, some being natural remnants and some man-made.

2.3.1. Nature and culture

Urban areas despite being human-dominated and urbanized with significant infrastructure, buildings and other man-made constructions, still often contain remnants of previous habitats and ecological patches. Therefore general urban quality in terms of green space relates to their utilization and whether these areas are preserved as natural or cultural.

"*Nature [has] included the biological patterns and physical processes entwined in vegetation, wildlife, populations, species richness, wind, water, wetlands and aquatic communities", whereas "culture [has] integrated the diverse human dimensions of economics, aesthetics, community social patterns, recreation, transportation and sewage/waste handling*"

(Dramstad et al., 1996, p. 10).

Additionally, anything that human beings cannot create is defined as nature. As such, nature has function and structure and is subject to change over time because the contents of nature move, flow, and shift forms. Ecosystems, resources and working systems are all part of nature (Richard T.T. Forman, 2008).

However, despite their management and establishment by people, there exist several features in urban areas that are classified as natural ecosystems, such as street trees, lawns, parks, urban forests, cultivated land, wetlands, sea, lakes, and streams, although this is a crude classification that does not account for ecological quality (Gregory Mc Pherson, 1992). As an example, despite fragmentation, remnants of nature can persist within areas for cultural purposes depending on how their management preserves them, including conservation of native species.

2.3.2 The urban landscape concept

Ecological theory is applicable across different locations. The principles of landscape and ecology apply from the rural with its larger number of natural areas to urban areas with more human influence. Accordingly, the urban landscape consists of basic systems and elements as in other types of landscape. The arrangements of elements within an urban landscape builds the landscape structure, accommodating the mobility and flow of the biotic and non-biotic components, with all their dynamics in spatial patterns over time (Dramstad et al., 1996). The basic elements of the landscape (patch, corridor and matrix) in an urban area are shown in Figure 2.2.

Figure 2.2. Three basic elements in landscape ecology (Source: Bentrup (2008))

As seen in Figure 2.2 a *patch* is an area which is non-linear, with a distinct structure that differs from its surroundings, giving it a different function from these. Patches can be small or large, and within an urban landscape they can be few or numerous, dispersed or clustered. *Corridors* are linear, in the form of a strip of a particular functioning type that is different from its surroundings on both sides. The linear form, which could be wide or narrow, connected or disconnected, contributes to the special ecological function of the corridor. A *Matrix* is basically the background to patches and corridors, characterized by extensive cover. These elements combine to form a *mosaic* which could typify a particular landscape (Bentrup, 2008; Dramstad et al., 1996; Richard T. T. Forman, 1995).

The patch, corridor, and matrix mix in urban areas can be natural, built or a combination of both (Aminzadeh & Khansefid, 2010; Cook, 2002). Natural vegetation, water bodies, rivers, and streams are examples of natural items. In contrast, built features are always artificial however closely they are made to resemble natural ones, although ecological interaction can be fostered by interweaving natural and built elements (Aminzadeh & Khansefid, 2010).

2.4. Urban spaces

This thesis is focused on the part of the urban area Swanwick et al (2003) termed the external environment outside building (Figure 2.3.). The focus is on urban green spaces in their many forms.

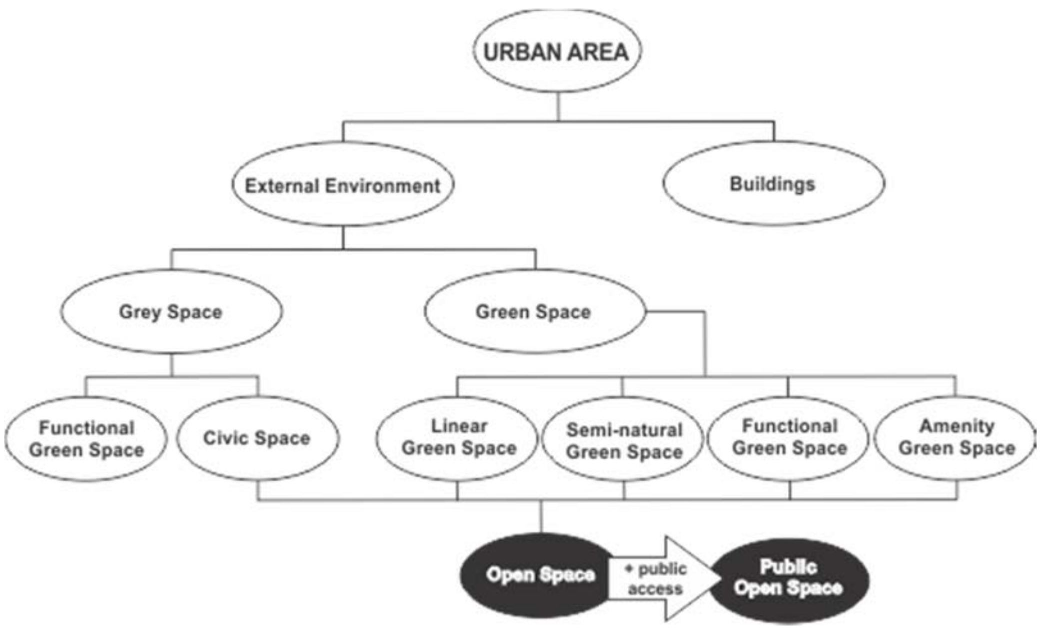

Figure 2.3. Space classification in an urban area. (Source: Swanwick et al (2003))

2.4.1. Urban green spaces

Urban green space has been defined in various ways, for example according to its physical attributes, content, and boundaries or location of the site (Barnett, Doherty, & Beaty, 2005; Harrison, Burgess, Millward, & Dawe, 1995; Singh et al., 2010). Other definitions relate to the use and function of the green space (Pullen, 1977), based on the idea that green space cannot be classified before its functions are clarified, regardless of its size, location and physical characteristics.

Additionally, it is useful to develop a typology of urban green space, not only in terms of physical shape, function and roles, but also in terms of maintenance and management (Carmona et al., 2004; Swanwick et al., 2003). Such a typology will help in determining the suitability of each green space for specific purposes.

Table 2.1. Urban green space definitions

Definition and dimension of urban green space	**Source**
"the range of urban vegetation including not only parks and open space, but street trees, residential gardens, and in fact any vegetation found in the urban environment, thus ignores tenure and composition or whether it is in public or private ownership or whether it is indigenous or exotic"	(Barnett et al., 2005, p. 3)
"Land, water and geological features which have been naturally colonized by plants and animals and which are accessible on foot to large numbers of residents"	(Harrison et al., 1995, p. 232)
"… Real systems of spaces - not just leftover green areas unsuitable for investment - must be embedded within the sustainability framework. Connected units in local, regional and national networks, which do not require constant human activity to survive…. have an environmental role…. and social functions"	(Szacki (1988) cited in Ryan & Wayuparb (2004, pp. 224-225))
"Urban green spaces are increasingly understood to mean the green areas within the overarching term of open space in many forms including public parks and gardens; play areas; natural green spaces, wildlife, ecology and woodland areas; amenity green spaces; functional green spaces; green corridors; greening of urban vacant and derelict land; and also private green spaces which benefit the public"	(Urban Green Spaces Taskforce, 2006, p. 5)
"a comprehensive term, comprising all urban parks, forests and related vegetation that add value to the inhabitants in an urban area"	(Singh et al., 2010, p. 6)
"Natural areas, parks, trails, greenways, and other types of open space that are not developed; can preserve natural ecological values and functions and provide places for resource-based recreation and other forms of human enjoyment"	(Benedict & Mahon, 2006, p. 282)

Comparing the definitions in Table 2.1, it appears generally green spaces are seen as any feature with a natural quality, whether natural or artificial, as long as they contain natural elements and show natural processes, which overall provide the experience of contact with nature.

2.4.2. Public spaces

In a city like Makassar where accessible public parks are limited, urban public parks are often equated with urban green spaces, while alternatively urban parks are often thought of as part of urban green spaces (Hidayansyah, 2007). This thesis uses the latter approach because when the characteristics of a particular green space are refined and specified, this will lead to a variety of different types. The definitions in Table 2.1 do not distinguish between whether a space is public or private, but from a land management aspect, the land status is important.

Beyond the owner or the controller status, there are other understandings of what public space is. Regarding function (Budiyono, 2006) public space should contain the three qualities of being responsive, democratic, and meaningful. Responsive means public space can accommodate a variety of activities and interests. Democratic refers to the fact that since public space is established with public money, it should be usable by a people with a variety of social, economic, and cultural backgrounds and accessible to all, whatever their physical condition. Meaningful means the public space should have a link between people, and broader local and global social contexts and cultures.

Nevertheless, despite a general understanding of public space as space owned and managed by the authorities, often in third world countries public space, such as neighbourhood space, is seen as nobody's land, being a secondary space not owned by an individual or the city, which is not inviting and thus ignored (Ghazzeh, 1996). Therefore the city council has a role in managing public space by involving communities to invoke a sense of belonging and care towards such spaces.

Although private gardens can serve the function of urban green space by giving access to nature, they lack the social and interaction value with other members of the community that is a quality of good public space (Barbosa et al., 2007).

2.4.3. Urban forest

There are many types of public space such as playgrounds, cemeteries, open fields and other types of natural and cultural public fields (Hidayansyah, 2007). These different land uses will be further considered and classified in the construction of a typology of spaces in Makassar (see Chapter 5). Urban forests, however, are considered a special feature because such forests are believed to be rich in nature as they are based on concepts of traditional forestry with a new approach in the shape of sustainable ecosystem based management for single or multiple use (Konijnendijk, 2003). Helms (1998) in Konijnendijk (2000, p. 91) defines urban forestry as "*the art, science and technology of managing trees and forest resources in and around urban community ecosystems for the physiological, sociological, economic and aesthetic benefits trees provide to society*". Taking a further perspective will go beyond resource consideration to see other spaces dominated by trees as part of urban forestry (Konijnendijk, 2003).

Understanding their significance for urban areas, urban forests with all their vegetation richness have been recognized and become part of cities (Yang, Zhao, McBride, & Gong, 2009). The urban forest concept first emerged from Erik Jorgensen in 1965, and the term 'urban forestry' was first used as the title of a report on the tree planting program of Toronto (W. Zhang, Zhang, Li, & Zhang, 2007, p. 44).

The introduction of forestry to urban areas basically emerged as a response to structural change to forestry due to urbanization, and as a method of providing compensation for forest loss, which had a clear impact in Europe. However, there are many definitions of an urban forest which vary according to the country (Konijnendijk, 2003, p. 178). The traditional meaning of 'forest' is often broadened by including within it small woods, parks, and gardens, as well as individual trees for attributes such area size and canopy coverage area (Konijnendijk, 2003). Basically, this is presenting the 'forest' at a smaller scale with a lesser level of wilderness and more amenities. The willingness to see such 'forest' in a less natural state also makes possible the creation of artificial forests in urban areas.

2.4.4. Private yards

A significant attribute of green spaces that might affect their management, and consequently their appearance, quality, and significance, is their ownership status. Public space is normally managed by the local council and shaped and given the function the authority wants. This approach is unlikely to succeed when it comes to private yards without establishing appropriate arrangements or agreements. On the other hand, identification of potential greenery in an urban area would normally include all visible green spaces, whether public or private, including house yards. According to Gaston, Warren, Thompson, & Smith (2005) house yards constitute a large part of ‘green space’ in urban areas and are of potential significance for the maintenance of biodiversity in cities. Because they contribute significantly to total urban green space (Barnett et al., 2005), private yards comprising house gardens and private property parks, which have previously been undervalued, have to be taken into account. Furthermore, these private gardens also serve as habitats for urban wildlife in the form of patches or corridors which can enhance the quality of urban green space. An example from the developing city of Leo’n in Nicaragua shows the significance of private urban patios which add up to 86% of all green spaces in the city (Singh et al., 2010).

Private green spaces become highly important when there is a significantly large area of residential plots with spaces that allow the residents to establish and preserve a neighbourhood garden aesthetic. Given this situation, and with the appropriate facilitation, they might replace the need for some public green space (Matthew McConnachie & Shackleton, 2010). Therefore, consideration of private yards and spaces is important for the benefit of the city as a whole. If a green approach is neglected in residential areas the city might lose a substantial amount of green space, as proven by a detailed assessment of loss of green space within a residential area over a 25 year period in Europe (Pauleit, 2003).

2.5. Benefits of urban green spaces

There are many forms of green spaces in urban areas, and their presence in these many forms constitutes part of the integrated processes of a city as an ecosystem.

Urban green spaces could be recognized and classified based on their characteristics such as size, content, function, and the benefits they offer as seen from various perspectives (Van Herzele & Wiedemann, 2003).

Provision of urban green space involves political interest and priority concerns when it comes to establishment and maintenance costs. The return on possibly expensive investment in green space provision has to be assessed against other priorities for each city. Although many studies have been undertaken with regard to human interaction with natural elements, the significance of benefits has yet to be fully acknowledged. Many arguments have been based on people's reflections that favour the benefits from surrounding natural settings, but these expressions are often made without proper measurement based justification (Barnett et al., 2005). Some of the research is poor (Pauleit, 2003), even in Europe (Handley et al., 2003). Dannenberg et al. (2003) suggest that until now much research has specifically looked at the adverse effect of an unfavorable environment on the health of urban citizens, rather than investigating the positive benefits. In addition where creditable research has uncovered the benefits of urban green space these are somewhat disregarded (Swanwick et al., 2003). Such benefits are defined as environmental, health, social and economic. In addition, the environmental service provided by urban greening could provide multiple benefits that intermingle within these categories.

Green space existence in an urban area is therefore important. However, merely providing the green space with all its manifestations is not enough for making a city more sustainable. Many requirements determine a sustainable green city, all working towards a system that involves all the components of the city. The successful green city is when the citizens also have green and sustainable behaviours, such as conserving energy and water and using public transport (Birch & Wachter, 2008). Dominski (1992) describes this process as the 'three stage evolution of eco cities', which involves actions that 'reduce, reuse and recycle'.

2.5.1. Environmental benefits

In regard to environmental benefits and functions, there are natural extractable resources and natural in place resources. Both are valuable to people, the first being for products for human use and the second for aesthetic and recreational value (Richard T.T. Forman, 2008).

Whereas urban greenery in any form can become an integrated and important part of cities, it can also be part of nature, being part of ecosystem networks at a larger scale. Despite the more common reputation of cities as being unfavorable to nature, with Odum (1971) in (Bolund & Hunhammar, 1999) describing cities as 'parasites in the biosphere', the existence of working natural ecosystems within urban areas could reconstruct the reputation of cities as the habitat of most people in the world.

Services of urban ecosystems can be identified as direct and indirect ecological services. Indirect services include the pollination of plants and nutrient cycling, whereas direct services are probably more important in urban areas because humans can take advantage of them. These include air filtering (gas regulation), micro-climate regulation, noise reduction (disturbance regulation), storm water drainage (water regulation), sewage treatment (waste treatment), and recreational cultural values. Other services that might be relevant to certain cities are food production and erosion control (Bolund & Hunhammar, 1999).

A fundamental problem that occurs in urban areas is deterioration of environmental quality. Many factors are responsible for this, but a big factor is the pollution that commonly results from urban activities. Some efforts to ameliorate urban air pollution have become part of municipal or state regulations in many countries. For example, in New Zealand and the UK, legislation demands the installation of catalytic converters, improvement to fuels, and vehicle testing (through the Ministry of Transport (MOT) in the UK and Warrant of Fitness (WOF) in New Zealand). However, because such efforts are only protective and not directly related with environmental factors, they are not enough for sustainability. It is still necessary to apply more effective measures to ensure a better quality of urban air (Jim & Chen, 2008; Ridder, 2004), using an integrated approach based on ecological landscape principles (R. H. G. Jongman, Hong, Nakagoshi, Fu, & Morimoto, 2007).

Several studies have been conducted around the role of the green component as an integral part of urban green space in reducing pollution in urban areas. A study in Guangzhou, China, concluded that where trees are the main feature of urban planting they could improve air quality by absorbing some air pollutants (Jim & Chen, 2008). In 2000, urban trees managed to discard 312.03Mg of air pollutants. Another study in the USA revealed annual removal of certain air pollutants by US urban trees totalled 711,000 tonnes. This pollution mitigation is just one among many ways vegetation affects urban air quality (Nowak, Crane, & Stevens, 2006). Air pollution is also mitigated by plants in parks (up to 80% of pollutants around the park) as well as by street trees which filter 70% of pollution from street sources (Bernatzky, 1983 cited in (Bolund & Hunhammar, 1999)). The pattern of existing vegetation in urban green space does make a difference to the optimal function of pollutant removal (Jim & Chen, 2008). Stout (1982) in (Bolund & Hunhammar, 1999) suggested trees are the more significant elements in urban planting for air pollution mitigation within urban areas, compared to grass and shrubs.

Ecological services can also have transferable benefits away from the source of the problem, for example CO_2 sequestration by urban trees can contribute to global climate change mitigation, or the benefit may be local, such as densely planted vegetation to reduce noise pollution.

Apart from the role of trees in pollution reduction in urban areas, it should also be noted that some tree species are capable of producing volatile organic compounds (VOCs) and carbon monoxide. However, the levels are very small, and the selection of trees with low levels of VOC emissions should reduce this effect (Jim & Chen, 2008).

The environmental benefits of urban green spaces through the function of trees and other vegetation are thus recognised. However, these benefits would probably be more significant if these spaces are working as a connected system.

2.5.2. Improving local comfort

As the main component of green spaces, trees are the elements which contribute to most of the environmental services provided. One of the services related with trees is their contribution to micro climates in towns or cities. Trees lower temperatures through evaporative cooling. Research in Germany confirmed trees lower temperature by 3–3.5ºC and intensify relative humidity by 5-10%, whilst providing oxygen which obviates bad odour and polluted air (Bernatzky, 1982).

Comfort from living in an environment near to or enclosed by green space can also come from the reduction of stress inducing factors. One annoyance in cities is traffic noise, and in Europe the presence of vegetation as forest or ground cover can mitigate the effect of noise 80m from the source. The same study also noted the importance of grassy and low vegetation in creating porous layers of foliage and leaf litter for a noise attenuation effect (Ridder, 2004). The study also confirmed densely vegetated parks reduce daily peak summer temperatures. This local effect in reducing heat stress is a complementing function of a park as a soothing and relaxing place.

2.5.3. Health benefits

For centuries natural elements such as plants in landscapes have been recognized through research as having a favorable effect on human beings physically and psychologically. The health benefits of urban green spaces are either perceived directly or indirectly through psychological improvement which leads to physical well-being. There is good scientific evidence for the benefits of attractive green landscape elements which justify their inclusion in hospital and health-care environments (Iswoyo, 2003).

Swanwick et. al (2003) have compiled the health-related benefits of urban green spaces from many sources. These range from engagement in outdoor exercise to the psychological effects of escaping from stress and experiencing a more relaxing environment. Among the benefits are improved human health and sense of well-being, stress reduction and productivity enhancement. Furthermore, Tzoulas et al. (2007) through epidemiological studies have proven a positive correlation between longevity and access to green space and between green space and self-reported health. Health benefits are also important for the elderly. In Japan cooperation between the authorities and a society of the elderly for golf course management is believed to have reduced the cost of healthcare for this group through improved social engagement and recreational amenities (Carmona et al., 2004). There are also health-related benefits from the soothing effect of nature experienced simply by viewing it or through sensory experience.

2.5.4. Social and educational benefits

Green space has been shown to be useful in promoting interactions between people from different socioeconomic and ethnic groups. The size of the green space affects the diversity of travel and how far people are prepared to go (Martin, Warren, & Kinzig, 2004). Thus improving cities by providing more green spaces should increase the quality of life and contribute to reducing social exclusion, especially for the poor, minority groups, and the least mobile. Opportunities for coming together in urban green spaces could result in development of culture and increasing identity and sense of community (Ridder, 2004).

However, another perspective has been brought forward by Solecki & Welch (1995) suggesting urban parks may function as green walls, or a boundary landscape which separate neighbourhoods of distinct socio-economic characteristics. If people sense this then the urban parks can lead to deprived neighbourhoods due to lack of use, possibly resulting in a derelict landscape. However, Gobster (1998) responded by suggesting the need to test the green walls hypothesis by looking at more than just the physical and biological measures of trees in a park. He insisted that by using alternative methods of analysis, some boundary parks are green magnets that can improve inter-racial connections.

The various opportunities for activities in urban parks boost their social function especially when accessibility is high for a vast range of users. This will improve social health through serving as a nearby resource for relaxation and recreation. The opportunity to experience different seasons and atmospheres provides an emotional amenity and comfort and softens urban life, as opposed to the hardness of structures and materials as the dominant view in cities (Heidt & Neef, 2008).

Urban green space such as parks and neighbourhood gardens are often a favourite place for children. Indeed, play is a requirement for them, thus it is important to provide space for this, otherwise they will occupy any space that accommodates their need for playing, even those that pose a safety risk, such as residential roads. More than just for play, urban green space contributes to the psychological development of children through outdoor, energetic, and imaginative activities, and the chance to meet others from different backgrounds. The latter may positively influence the behaviour of children as individuals and as members of society (Swanwick et al., 2003).

In 1861 Henry David Thoreau stated:

"*A river with its waterfalls and meadows, a lake, a hill, a cliff or individual rocks, a forest, and ancient trees standing singly. Such things are beautiful, they have a high use which dollars and cents never represent. If the inhabitants of a town were wise, they would seek to preserve these things, though at a considerable expense; for such things educate far more than any hired teachers or preachers, or any present recognized system of school education.*"

(Dramstad et al., 1996, p. 10)

Certainly, urban green spaces work both as informal and structured educational resources. They are spots for lifelong learning about the environment, nature and ecology along with all the processes within these (Heidt & Neef, 2008).

2.5.5. Economic benefits

The ecosystem services and environmental benefits of urban green spaces are sometimes overlooked though constantly perceived. This happens because the common appreciation of services normally relates to their monetary value, especially when it comes to political decisions and priorities, even in the face of residents expressing their appreciation of the amenity of green spaces as priceless.

2.5.5.1. Appreciating and valuing the benefits

Although science has clearly confirmed the role of natural processes in providing the essential life-support services from which humans gain benefit and on which they are highly dependent (Daily et al., 1997), such processes tend to be neglected because their values have not been clearly priced or sufficiently measured by commercial markets (Costanza et al., 1997). Additionally, most of the time the role of nature is undervalued as people never have to pay for its benefits (Gregory Mc Pherson, 1992).

One obstacle to valuing environmental services is the fact they are difficult to quantify (Gregory Mc Pherson, 1992). Their contribution to people's prosperity cannot be measured by conventional macroeconomic indicators as these ignore non-market services and the costs of natural capital depletion for the next generation (Howarth & Farber, 2002). Despite the difficulties in measuring benefits in monetary terms, much research has been aimed at attempting to disclose their economic value because when it comes to the political agenda, before any funding for natural capital investment can be made, everything has to be economically convincing. Therefore, research into market value equivalence is necessary to help authorities and political powers give more attention to and make more provision for natural settings and ecosystems in their decision making (Daily et al., 1997). This is because an evaluation method of urban green space benefits is important in justifying their significance relative to other types of infrastructure development in monetary terms (Gregory Mc Pherson, 1992).

Likewise the ecological and economic benefits of urban green space can be divided into direct and indirect benefits. Direct economic benefits are obtained under the economic value of the environmental service functions of any components of the green space. The indirect economic benefits are derived from the economic value gained due to the presence of the green space in an area. The direct economic value of urban green space can be estimated by employing marginal cost as a way to price the benefit. It means the cost of producing or generating one benefit or one substance (for instance air pollution abatement) is used to estimate the economic value of the service. This method was used by Jim & Chen (2008) for evaluating the air pollution removal service of urban trees.

Three methods have been proposed for evaluating indirect benefits (Gregory Mc Pherson, 1992) as listed below.

1. Travel cost method

   This method assesses the benefit by using the money people have to spend to visit the features. This is only effective when evaluating the benefit of distant parks and urban green spaces.
2. Contingent valuation

   Here the valuation is based on people's willingness to pay, which is compared to the real amount people are paying.
3. Hedonic pricing method

   This method is believed to be most effective because people's preferences are influenced by and reflect some of the off-site external benefits, such as pollution abatement, noise reduction, attractive view, and presence of wildlife. The hedonic pricing method assumes the value of the benefits by correlating costs and prices of market transactions.

Howarth & Farber (2002) have suggested the three methods could be used to generate a shadow price that represents the marginal contribution of the green space to human satisfaction in monetary units.

2.5.5.2. How much is gained?

In terms of appreciating the benefits of environmental services, they have to show an attractive economic profit to gain attention (Gregory Mc Pherson, 1992). Therefore, it is very important to document the value of all benefits in order to gain up front funding for green investment, rather than it being only given what is left over in the budget (Benedict & McMahon, 2002).

The role of natural capital should not be underestimated. One study estimated, the value of environmental services on average was 183% more than total global GDP (Costanza, et. al. 1997). However, this claim is debatable and has led to the accusation there has been an overvaluation of people's willingness to pay for the services and an underestimation of compensation from the loss of ecosystem services (Pearce, 1998). In addition, the method and specific data are provisional and open to criticism (Howarth & Farber, 2002).

Despite the debate regarding the magnitude of 'real monetary value',benefits do have economic value. A study in Ghuangzou, China estimated the annual value of air pollution removal by urban trees at US$744,969.4 (Jim & Chen, 2008), compared with US$3.3 million each year by the 6 million trees of Sacramento's urban forest (Mc Pherson, 1998) and the $3.8 billion value of pollutant removal by various US urban trees (Nowak et al., 2006). Another study identified 1675kg of air pollutants were removed by 19.8ha of green roofs in one year in Chicago (Yang, Yu, & Gong, 2008). The annual monetary value of pollutant removal by urban trees in the same city reached US$9.2 million.

The benefit of pollutant removal by trees in urban green space would also have significant economic value in cities in the developing world, as these cities usually have a limited budget for pollution abatement efforts.

In conclusion, most of the benefits of urban green space described above can also be explained as ecosystem services beneficial for humans within their living environment

(Costanza et al., 1997; De Groot, Wilson, & Boumans, 2002). In turn, the level of these benefits depends on the state of a green space in terms of its ecological richness and biodiversity (Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007).

2.6. Effects of urban development

Urban development is inevitable with population increase and no curb on demands for a rising economy, prosperity and modernization. As witnessed in many urban contexts around the world, this development has consequences for the natural environments that were once an integrated part of most urban areas. The two most observable impacts of urban development are the disruption and extermination of habitats and land use conflict between humans and other species.

2.6.1 Habitat loss and fragmentation

Urban development creates conflict in terms of land use priorities, currently leading to decisions which are mostly directed towards economic gain and unfortunately away from the ecological direction. Construction of infrastructure as a response to economic development demands land conversion in which urban wildlife habitats disappear. At this point, any remaining natural patches of habitat are vulnerable to encroachment, disturbance, division, perforation, and shrinking (Dramstad et al., 1996), leading to habitat attrition and possibly complete habitat loss. However, most development still spares some spaces for nature, and with thought these could favor wildlife preservation. The problem is most authorities are unaware of fragmentation and its consequences from an ecological point of view.

Leaving scattered small green spaces is a common effect of urban development and without connectivity this will create habitat isolation. Isolated and stranded species are unable to interact with other individuals, which will result in dwindling numbers and quality. Eventually without improvement, because of factors such as declining genetic diversity due to interbreeding (DeStefano, 2009), these species could potentially disappear. This effect has been named ’island biogeography‘ (DeStefano, 2009; Simberloff & Abele, 1982).

2.6.2. Conflicts of interest between wildlife and human needs

Conflicts of interest occur among various tropic levels of the ecosystem within the expanded zones. In many cases certain degrees of development will collide with natural interest in wildlife habitats, and breeding and feeding grounds. A CSIRO study revealed more than 50% of endangered Australian species of plants and animals inhabit areas around major cities and agriculutural areas (Barnett et al., 2005). Studies in Europe have found that in many cities up to 50% of species within inner areas are part of the urban flora (Harrison et al., 1995), therefore urban areas as wildlife habitats need to be maintained. Human conflict with wildlife is something that has become an integral issue of urban wildlife and biodiversity management (Savard, Clergeau, & Mennechez, 2000).

Another perspective on conflict, of which urban forests are an example, occurs as to whether they should be seen more as an industrial benefit or a societal use, which relates to ideas of values, perceptions and lifestyles, often occurring in the urban matrix between rural and less natural areas (Konijnendijk, 2000).

People living in urban areas can come to realize over time that their environment is changing greatly with development and growth, leading to the degradation of quality of life within the urban environment. The lack of connection with natural settings along with pressures and tensions as a result of the competitive life in cities has brought about more concern for the potential beneficial roles of getting close to green features, something that has been appreciated since the 19th century (Barnett et al., 2005; J. R. Linehan & Gross, 1998).

Among the beliefs in the goodness of nature for urban people is its restorative and salubrious quality, which is accepted by various cultures, leading to preservation and creation of natural elements (Parsons, 1991; Swanwick et al., 2003). Such beliefs started the garden city movement of Ebenezer Howard, followed by the garden association in 1899, two early well-known responses to improving urban design and town planning (Barnett et al., 2005).

2.7. Addressing urban growth problems

Despite the inevitable change due to urban growth, for the sake of ecology and social and economic functions the ideal is to let all processes run in parallel with the support of the landscape structure. Such a synergy would generate the required services for people, allowing the landscape to change yet preserving the key resources in a process involving all stakeholders and powers. These are some of the requirements of a sustainable landscape (Opdam, Steingröver, & Rooij, 2006).

People living in urban area have similar needs to those in rural areas in terms of connection with nature. They need to have ways of recovering from a hectic urban life. They need varied activities and those related to the outdoors are preferred as people then find their stress and headaches decrease significantly, while a well-balanced feeling increases. In one study headache reduction level was 52% and stress recovery ratio was 87% (Hansmann, Hug, & Seeland, 2007).

The need for natural settings and demand for nature around urban living places is deepening. City dwellers have to acknowledge that access to nature is often difficult and not easy and cheap to attain. Sometimes visiting rural areas or distant natural parks is the only, expensive option for city dwellers. Urban people are increasingly dependent on more distant and expensive resources (Richard T.T. Forman, 2008). Although more humans now and will continue to live in urban areas, they are as much as dependent on nature as rural people (Bolund & Hunhammar, 1999).

The principle that lies behind ecology based development is the ability to combine and harmoniously link nature and human beings, effectively linking ecology with all its relevant functions with human culture. Frederick Law Olmsted emphasized the connectedness of human beings and nature as people are biologically set to react physiologically in a positive way towards pristine environments, just like other mammals (Dramstad et al., 1996).

2.7.1. International and government consensus

In 1992, a Conference on Environment and Development (UNCED) was held by the United Nations in Rio de Janeiro, Brazil. This event produced the Convention on Biological Diversity (CBD) which aimed at a worldwide collaboration for tackling the problem of biodiversity loss (Sandstrom, 2008, pp. 9-10). Although initially triggered by concern for biodiversity deterioration, this convention also led to considering the creation of urban areas with less detrimental impact on biodiversity, while at the same time being more comfortable for people through the establishment of amenity features.

Governing authorities need to address and respond to the issue of bringing nature closer to urban people. Because global human population is mostly living in urban settlements, urban areas must provide the necessary natural experiences on a daily basis (Handley et al., 2003). In other words, governments and decision makers should achieve a balance between ecological, cultural and economic functions within urban areas (J. R. Linehan & Gross, 1998).

The main idea of making urban areas with spaces for both nature and human beings is so that they both share the space and benefit each other, "*the core objective is to mesh nature and people so they both thrive*" (Forman, 2004 in Richard T.T. Forman (2008, p. 4).

With the growing city phenomenon around the world, natural ecosystems must be put as the priority in any decision making because of their contribution to human welfare. However, it is not enough merely to scatter some spots of green vegetation within an urban boundary without maintaining proper standards in terms of size and related potential biodiversity (Costanza et al., 1997).

2.7.2. Green infrastructure

Green infrastructure has been examined from various points of view. It has been regarded as closely relating to natural features such as trees and other vegetation with certain ecological benefits for humans within the urban context (Benedict & Mahon, 2006). Using a more technical and practical definition, urban green infrastructure is defined as engineered structures in urban areas that are designed to achieve, to an extent, an existence in accordance with environmental goals (Benedict & Mahon, 2006, p. 1). Given the complexity within urban environments, green infrastructure should be seen as an ecological framework for natural life-support systems for human beings.

Although worldwide urban green space is seen as an important feature of modern cities in response to environmental concerns, it is not the existence of green space which has biggest role in urban ecosystems. Emphasis must be given to the function of the green space. On the other hand, access to whatever features provide ecosystem services and amenities in an urban setting is important. In this context although green spaces are important features of the city, a network which provides access to them is essential. Therefore, the creation of green connectivity is the most relevant approach (Benedict & Mahon, 2006).

The term ‘green infrastructure’ is in contrast with ‘built infrastructure’. It is basically counterpointing the linked items of hard structure and man-made construction, such as streets:

“*…it connects natural life support systems (waterways, wetlands, woodlands, wildlife habitats and other natural areas); greenways, parks and other conservation lands; working farms, ranches and forests; wilderness and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources and contribute to the health and quality of life for communities and people.*”

(Benedict & McMahon, 2002, p. 12).

In terms of benefits, green infrastructure as a concept can act to guide planning and management in order to establish a sustainable system that is capable of connecting green spaces without disregarding aspects of conservation and recreational values for people. From the point of view of a timeframe, it links present and future resources. Green infrastructure is known as a popular framework (Wickham, Riitters, Wade, & Vogt, 2010) which creates a mechanism which combines various interests for the same goal in terms of land protection. As an action, the approach is a framework that anticipates future growth and land development, and conservation as a response to population growth and as a measure of preserving community assets and natural resources (Benedict & Mahon, 2006, p. 3).

2.7.3. Greenways and ecological networks

Various terms are given to different features that serve to bring the natural environment into urban areas. These terms basically refer to features with a similar function, but which appear in different terminologies based on location and time. The terms have evolved around two main words ‘ecology’ and ‘green’.

As concepts of concern for the natural environment within the development issue, greenways and ecological networks have been established and implemented in the developed world. These concepts, which together are often described as ‘ecological infrastructure’ or ‘green infrastructure’, were introduced over two decades ago (Hailong, Dihua, & Xili, 2005) and nowadays have become a reality, or at least have a place for consideration among various authorities (Benedict & McMahon, 2002); (Benedict & Mahon, 2006). At this level, the concept has been widely translated into an integrated network system of open spaces which could serve ecological and environmental functions for the sake and benefit of people and biodiversity.

The greenway and ecological network are two terms derived from two development approaches. The greenway concept was introduced in the United States to answer the need for connecting the city with the countryside, or to link urban and rural areas. Greenways can be seen in projects in the USA and Europe (Section 2.7.4.1). On the other hand, the ecological network grew up in Europe, originating in the Netherlands mainly for conservation purposes (R. Jongman & Pungetti, 2004) (Section 2.7.4.2).

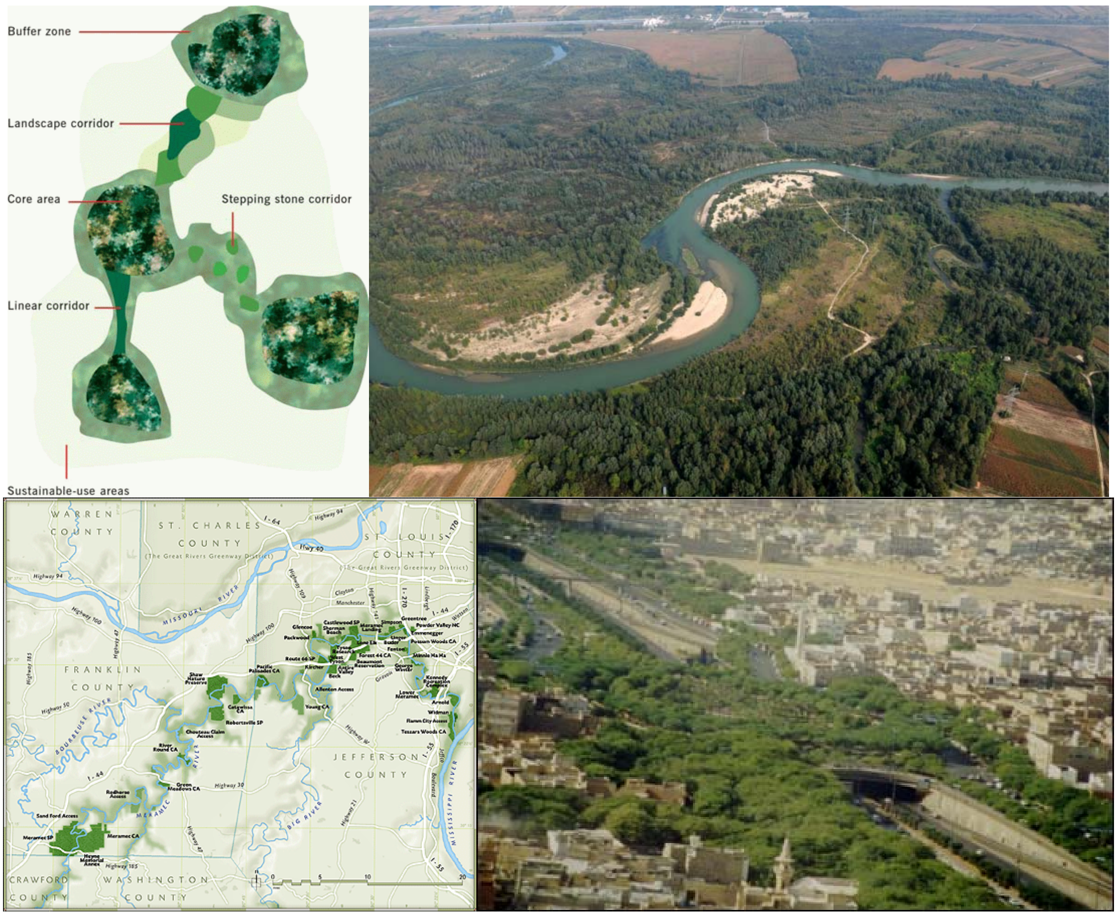

Figure 2.4. An example of ecological network (top) and greenway (bottom).
Source: (Bennett, 2004)

2.7.3.1. Greenways

The concept of greenways was derived from the idea of providing more benefits for people from linking parks together. The concept was inspired by Frederick Law Olmsted who said, "*No single park, no matter how large and how well designed, would provide the citizens with the beneficial influences of nature, parks needed to be linked to one another and to surrounding residential neighborhoods*." This idea triggered the modern greenways movement (Benedict & McMahon, 2002, p. 13).

Fabos (2004) simply defines greenways as ecologically significant corridors with specific functions and values. In accordance with American terminology of landscape architecture and planning, Little (1990) is more specific in defining a greenway as: "*linear open space established along either a natural corridor, such as a riverfront, stream valley, or ridgeline, or overland along a railroad right-of-way converted to recreational use, a canal, a scenic road, or other route*" (Little (1990) in R. Jongman & Pungetti (2004)).

Providing green infrastructure or greenways is not just a government issue. Their success depends on collaboration between many sectors and communities, with the government as the overseeing agent in many cases. Green infrastructure is wider than greenways in terms of ecological goals, yet a greenway might be an important component of green infrastructure (Benedict & Mahon, 2006). Greenways can be integrated with and complement parts of ecological networks (Section 2.7.3.2), adding up to wider network functions beyond just ecological processes (Opdam et al., 2006).

2.7.3.2. Ecological networks

Historically, applying the term 'ecology' to networks started in the Netherlands 25 years ago, with the term **ecological infrastructure** (Hailong et al., 2005). This term appeared as a description of stream corridors with connecting green spaces that at the same time were performing with a high level of ecological function. As such these features became ecological infrastructure as a framework closely related to a cultivated and developed landscape. Therefore, it has similarities to power infrastructure.

Because the term infrastructure is also associated with man-made structures, over time the term became uncomfortable for many people, and was changed to **ecological**

networks, a term that has been used in European for some time. An ecological network is capable of integrating landscapes and habitats for the sake of ecology and biodiversity (Hepcan, Hepcan, Bouwma, Jongman, & Özkan, 2009).

In order to be conserved, biodiversity needs a coherent spatial ecosystem structure within urban and other human dominated landscapes. It does not have to be a huge single space with all living resources in it, but can be a networked system of several sites or hubs with different characters and features capable of sustaining plant or animal species and populations. All ecological networks are close to development, meaning they require change and conservation efforts to take place at the same time. With the ecological network approach, biodiversity is no longer a forbidden topic for urban developers and decision makers, but can be used to achieve win-win solutions with ecologists and environmentalists (Opdam et al., 2006).

In an urban context, the term ecological network might depend on defining the specific type of ecosystem to be established. Opdam et al. (2006) described ecological networks as a set of ecosystem types linked through the landscape to the interacting flows of organisms. Therefore, to achieve biodiversity, the network should be more than a single habitat network, with only a single species (Hobbs (2002) in (Opdam et al., 2006). The ecological network approach is aimed at accommodating development in urban areas with conservation of natural value by protecting and mitigating the effect of urban growth (Aminzadeh & Khansefid, 2010).

Table 2.2 collects together various definitions and descriptions of an ecological network. However, a common aspect emerges, which is the inclusion of essential elements, namely core areas, protection/buffer zones and connecting features (corridors). These elements are necessary for the ecosystem, habitat and landscape (Boitani, Falcucci, Maiorano, & Rondinini, 2007).

Table 2.2. A comparison of ecological network terminology

Expressions of Ecological Network	**Source**
"Scattered habitat patches within a network which contains nodes and links that stimulate landscape suitability as perceived by different organisms"	(Andersson & Bodin, 2009, p. 123)
"Systems of nature reserves and their interconnections that make a fragmented natural system coherent, so as to support more biological diversity than in its non-connected form, composed of core areas, (usually protected by) buffer zones and (connected through) ecological corridors"	Bischoff and]ongman (1993) in (R. Jongman & Pungetti, 2004, p. 24)
"A coherent system of natural and/or semi-natural landscape elements that is configured and managed with the objective of maintaining or restoring ecological functions as a means to conserve biodiversity while also providing appropriate opportunities for the sustainable use of natural resources"	(Bennett, 2004, p. 6)
"Ensemble of environmental elements with heterogeneous physical and biological features that maintain their structural and functional heterogeneity regardless of human activity"	(Blasi et al., 2008, p. 540)
"A system of areas between which not only ecological but also physical links exist, usually consists of the following elements: core areas, corridors, buffer areas and, in some cases, nature development or restoration areas"	(Zingstra et al., 2009, p. 12)
"A network of lands that is designed to conserve native ecosystems and landscapes, restore connectivity among native ecological systems and processes, and maintain the ability of ecosystems and landscapes to function as dynamic systems and to allow biota to adapt to future environmental changes'	(Benedict & Mahon, 2006, p. 280)

Another significant commonality is the significance of the network component. This leads to the following definition of an ecological network for this research: "An ecological network consists of series of ecological patches which are connected by linear corridors or small green spots within reachable range serving as stepping stones; with function that is highly dependent on the nature of the patches as places for species to reside permanently or temporarily and corridors as accommodating pathways for species movement and migration."

Figure 2.5 is a simple illustration of how the greenway and ecological concepts merge into the urban matrix.

Figure 2.5. Ecological network (left) with possible species movement (black, yellow and blue lines) and greenways (right) with possible people access to more natural areas in the countryside (red lines)

2.7.3.3. Planning for implementation of an ecological network

Jongman et. al (2007) emphasise the importance of accommodating and integrating many aspects and processes in order to achieve an ecological network, as shown Figure 2.6.

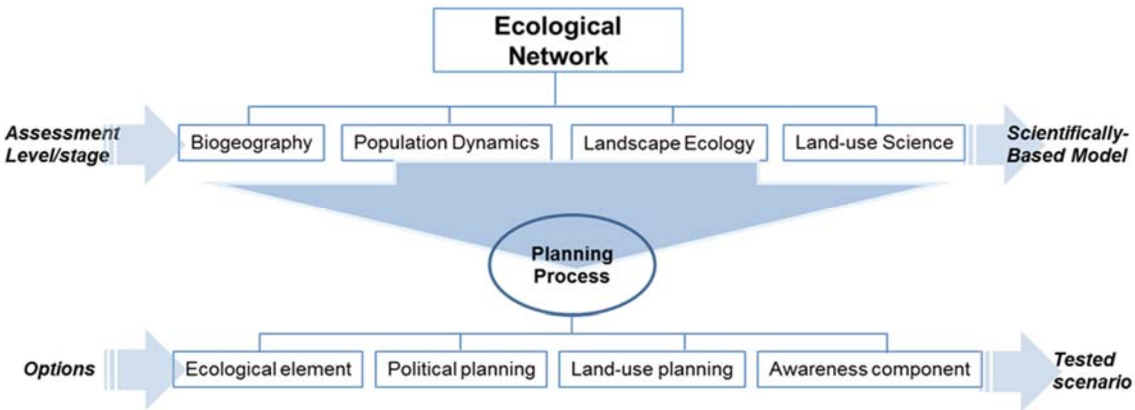

Figure 2.6. Aspects and processes in creating an ecological network

Creating an ecological network is a development process that integrates ecological science and societal processes. The process starts at the assessment level where several factors must be precisely observed. Physical and biological conditions along with the site content are part of analysis before a model can be proposed. The result should be acceptable and accountable to the public because the considerations are based on scientific findings.

A model will then be prepared for implementation through the planning process. Again, this process should consider several factors. The first factor is the ecological element comprising biotic and abiotic factors. Cook (2002) stressed the significance of assessing ecological content and size before being able to evaluate variability and vulnerability. The other factors relate to policy, planning and community acceptance and willingness to support the concept.

Implementation of an ecological network is a major and possibly expensive decision, so there is the challenge of gaining political support from decision makers and authorities. Therefore, success stories from other places will probably be needed to persuade those in charge. Hopefully, the acceptance will not be just a political gesture, but will alter policy, regulations and budget provision accordingly.

Landscape dynamics are influenced by natural and external factors (Richard T.T. Forman, 2008). Among external factors is disturbance through human activities. Therefore consideration of land use along with assessment of potential change in the future is an important consideration in ecological network planning. This will prepare the landscape so it can either accommodate change or compensate possible disturbances by opening other new sites.

The last factor to consider in the planning process is people's acceptance of the concept and plan. It is not only the authorities that need to be convinced as other stakeholders are also an important component in successful ecological networks. When people are aware of the significance of a network and what it can provide for them they should support the program and help to ensure its sustainability. One way of gathering the support of people is by involving them in the process. This could be through surveying their preferences, or having them more involved through a participatory approach or participatory planning procedures (Drijver, 1991; Oakley, 1991; Zanen & de Groot, 1991).

Jongman (2007) proposed a recipe for implementation based on how the concept is developed within a framework such that all stages are fulfilled, advancing one after another or simultaneously. This is only possible if these ecological concepts have been understood and acknowledged by all parties involved in the planning system. This seems to be the case in the developed world where acceptance of the concept with financial and political support make implementation possible. It could be different for a less develop context where these concepts have not been tested and hence are not familiar. Setting out the implementation stages to initiate the idea might be a first significant step.

2.7.4. Selected examples of greenways and ecological networks

The extent of the application of greenways and ecological networks varies across countries and nations because of many variables and affecting factors, notably level of wealth and how advanced the nations are in terms of development and technologies. These are what later determine whether a nation is classified as developed or developing in implementing or adapting the concept of linked urban green spaces.

Both greenways and ecological networks are concepts initiated in developed countries. Therefore their implementation in developed cities is more advanced, resulting from years of experience and improvement. Starting as a concept which evolved through the visions of landscape architects in America in the 19^{th} and 20^{th} century (Fábos, 2004), there are many examples of greenway projects in the USA at various levels. The ecological network developed later post 1980, especially in Europe, after landscape ecology was acknowledged as part of the discipline of ecology.

In Europe, governments started to give political attention to ecological networks after the Council of Europe produced technical information through the plan for the Pan-European Ecological Network, and this opened the way to more initiatives for ecological networks across Europe (Boitani et al., 2007). The greenway is not exclusive to the USA and is also found in Europe, where its spread has been influenced by geographical, economic, and cultural differences. Urban and social development has also determined acceptance of the concept, marked by the establishment of the European Greenway Association back in 1998 (Toccolini, Fumagalli, & Senes, 2006).

2.7.4.1. The New England Greenway Vision Plan

The New England Greenway Vision Plan is a compilation of existing and proposed greenways in six states in the north eastern corner of the USA that set out to identify significant linkages for creation of a regional system (American Society of Landscape Architects, 1999; Fabos, 1995). This project is a good example of how such a plan necessarily involves many parties. Initiatives are derived from all related stakeholders with the intention of creating greenways which are accessible to everyone. Planning is based on existing data about the condition of all the states in New England.

The three main objectives of the greenways vision for this project are:

1) to make greenways as accessible as roads;

2) to boost the tourism industry without detrimental effect on the environment and:

3) to maintain and even improve the quality of the environment in the region.

As a result the plan includes harmonization of both natural and cultural landscapes. What makes this work accountable and able to gain support from people is the opportunity for involvement which was given to the community. This is reflected in the planning process which involved proposals from different sources and institutions prior to the creation of a final design based on all considerations and interests. Apart from proposing new greenways for the region by optimizing the existing ones the project also produced maps for trails and greenways within historical and cultural corridors.

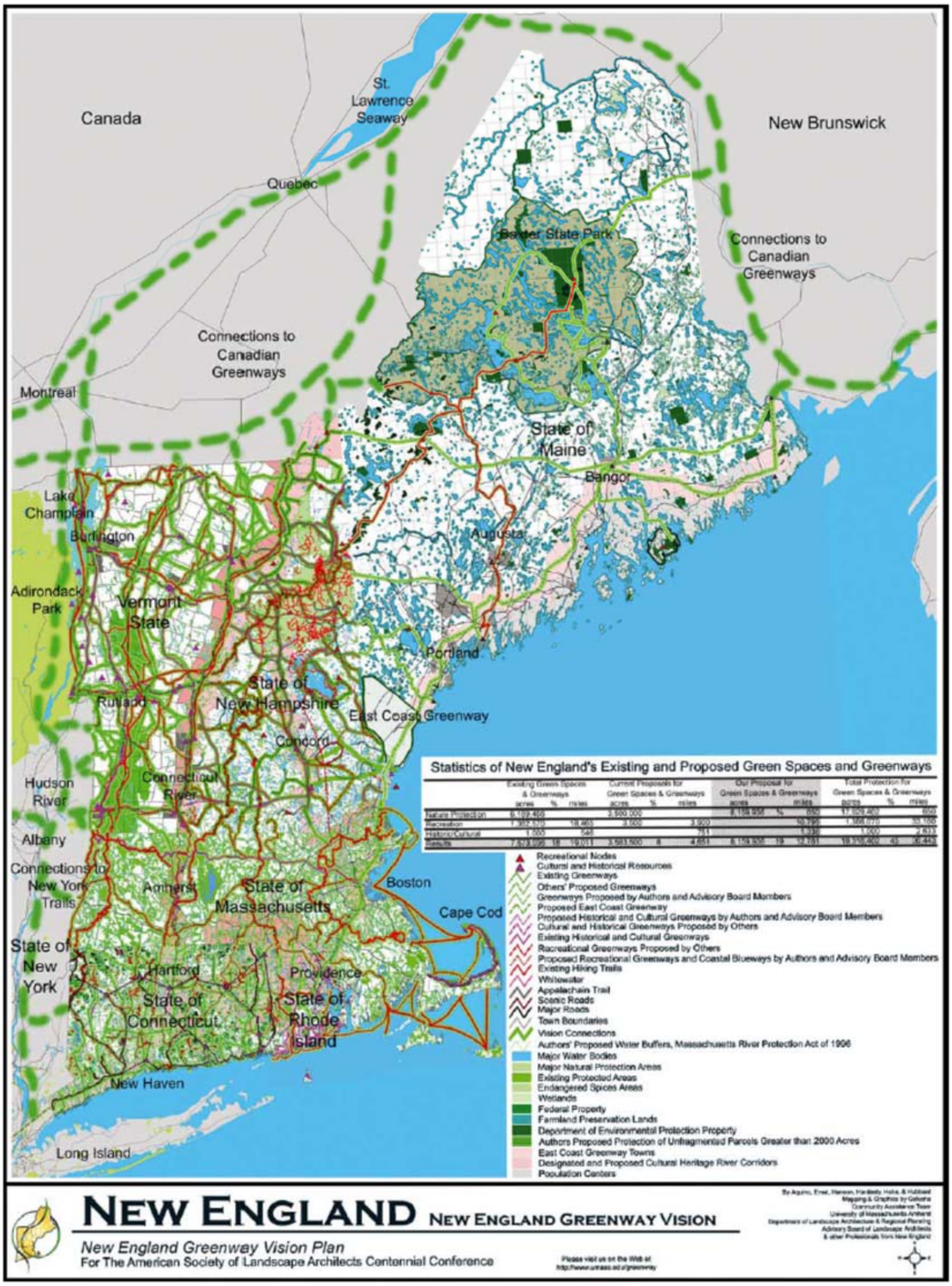

Figure 2.7. Greenway vision plan for New England
(Source: American Society of Landscape Architects (1999) and Fabos (2004))

2.7.4.2. Implementation of ecological networks in the Netherlands

The development of ecological networks in the Netherlands is an example of implementation beyond regional administrative borders to make a national scale plan. This national project was started in 1990 when the Dutch parliament approved a long term nature policy plan aimed at conservation, rehabilitation and development of nature and landscape (R. Jongman, Bogers, & Alterra, 2008). This was the root of the development of the National Ecological Network (NEN) involving all provinces through the determination of the exact boundaries of the network (Natura, 2000). The network covers various areas of natural, developed, and cultural landscape, with the target of developing 150,000 hectares of new nature areas and 100,000 hectares of environmentally friendly agricultural areas by 2018, covering 20% of the countryside in the nation (Agency-PBL, 2012).

In order to achieve the targets, apart from preserving the existing ecological areas, new areas are procured through conversion of land use to a more natural function, and this includes buying land or long-term contracting of private land and farms (Natura, 2000). 'The Renkumse Poort' is a good example (Bennett & Mulongoy, 2006; Natura, 2000) of how the insistence on restoring ecological linkages has overcome economic interests, a hard decision for most political powers to make. Reclaiming a nature corridor was made possible by 'sacrificing' two motorways and a railway and demolishing an industrial area (Bennett & Mulongoy, 2006), to make way for a fauna corridor for animals such as red deer and other small mammals and amphibians (R. Jongman et al., 2008).

Figure 2.8. The Renkumse Poort restoration
(Source: Bennett & Mulongoy (2006))

The example in Figure 2.8 is something special and could be an unusual occurrence for people in other contexts, such as in the developing world, as here development is usually the other way round, with natural areas being ‘sacrificed’ for the establishment of industrial areas, infrastructure or other urbanization projects.

Reclaiming spaces for natural corridors has become a common approach in the Netherlands. In fact this country was among of the first to establish networks for wildlife across the landscape (ARC Partnership, 2012), solving conflicts with infrastructure by the introduction of animal crossings (Figure 2.9.).

Similar to greenways in the USA, one key to the success of the wider and long term implementation of ecological networks in the Netherlands is the involvement of many parties, partners and various levels of stakeholders in conflict resolution and solution formation. Projects are realized because of eased funding mechanisms as a result of the adoption and acceptance of this national campaign by stakeholders as well as the general public. This has allowed the program to run for nearly twenty years (R. Jongman et al., 2008).

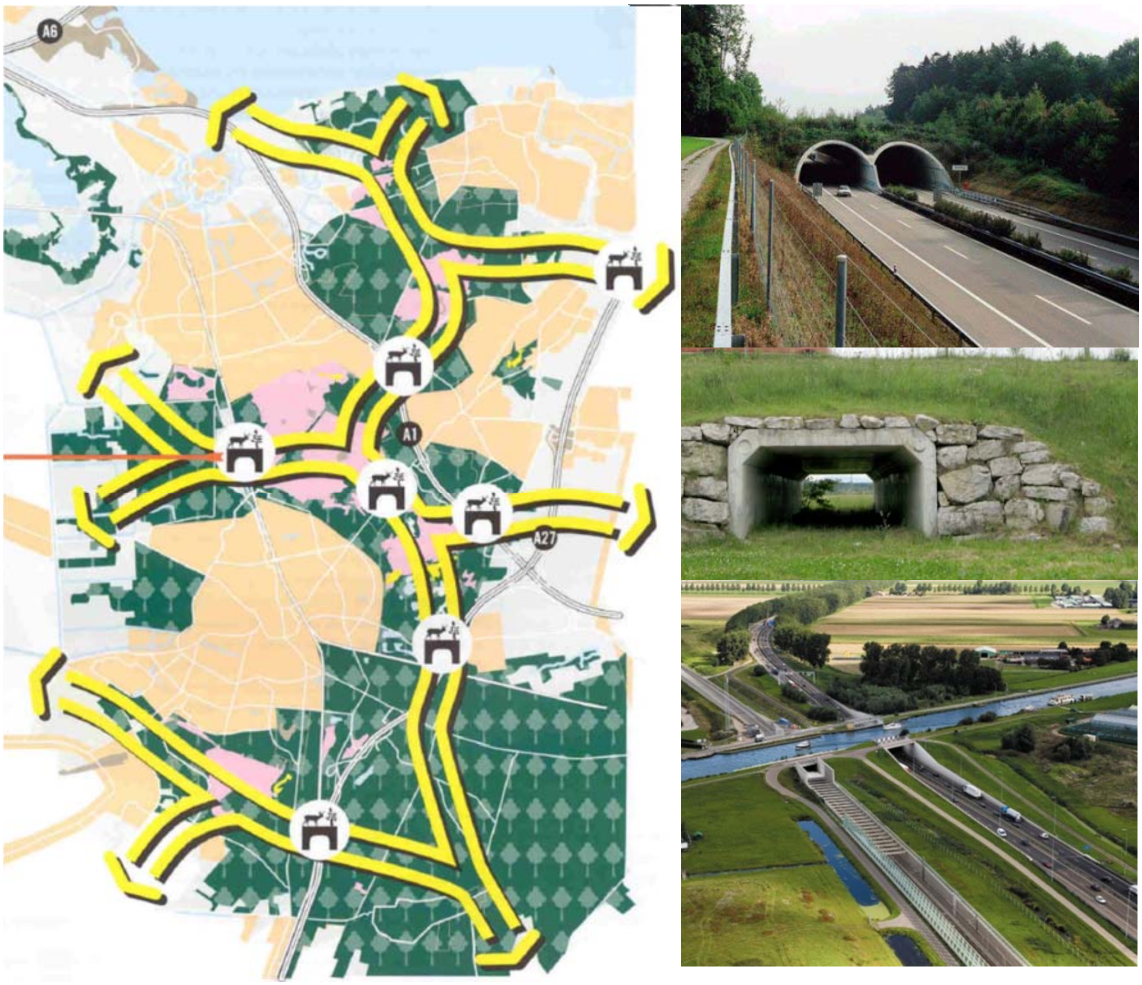

Figure 2.9. ‘Nature bridges and tunnels’ in the Netherlands allowing movement of terrestrial as well as water species across landscapes
(Source: Natura (2000); ARC Partnership (2012))

Despite the fact natural areas are the most important concern for the whole network the NEN remains accessible for multi-functional use. However, level of use for certain areas is highly dependent on the sensitivity of the area. Therefore, planning for multi-use is undertaken carefully by taking account of local nature objectives (Natura, 2000).

Wildlife is not segregated based on national boundaries. Within wider landscapes in Europe species movement is across borders. In the context of animal movement, there is no such term as Dutch deer, German snakes or Belgian frogs. This understanding has been agreed by governments in Europe through which the The Pan-European Ecological Network (PEEN) has been established, including 42 ecological network initiatives and 7 NENs across Europe (Boitani et al., 2007).

Figure 2.10. Dutch National Ecological Network (NEN) showing both terrestrial and water networks (Source: Natura (2000))

The networking of a site with adjacent areas can cross geographical and administrative borders, hence ecological networks make possible broader links across islands and even nations (Rob H. G. Jongman et al., 2004).

The Dutch NEN has helped this country to meet several international obligations. The plan goes beyond national borders to connect with nature areas in Germany and Belgium. Cooperation between countries is essential with respect to biodiversity policy and prevention of loss of natural habitats at multi-national level (Natura, 2000). The Dutch NEN is part of the Western Europe PEEN (Figure 2.11.).

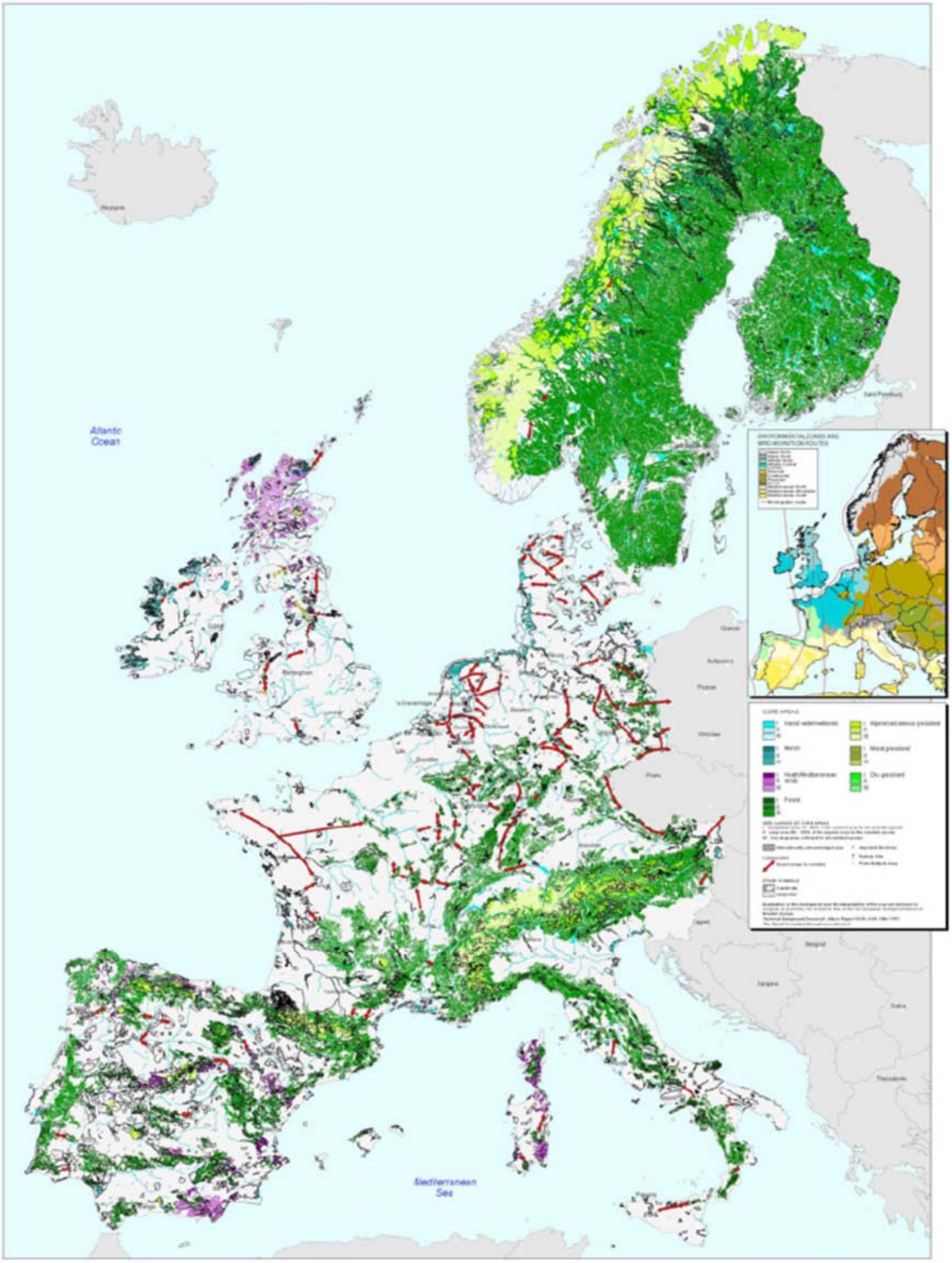

Figure 2.11. Indicative map of Western Europe Pan European Ecological Network
(Source: Jongman, et. al. (2011))

2.7.4.3. Lambro River Valley Greenways System - a European greenways project

The greenway plan for the Lambro River valley park (Toccolini et al., 2006) is mainly aimed at preserving natural areas along the river, as well as preserving the historical elements which remain as the witness to historic development in the area over several centuries. Located north of Milan the project was initially targeted at creating a green trails network within the river park in order to connect people with the natural resources, and to make a non-car route for daily journeys. Study prior to the project identified that the inclusion of a wider area beyond the official boundary of the park was essential for a viable system. Eventually the scheme included the whole area of the park and nearby land covering $235km^2$.

By analyzing and assessing existing elements such as green trails, the greenway plan identified missing links and the efforts required for improving and connecting the existing networks. Figure 2.12 shows the existing green networks and the greenway plan for accommodating them. After the assessment, it appeared that 80% of the network already existed, so the proposed improvement basically optimized the existing, for example by creating a network that rediscovered old historic routes, or a new non-motorized route that enabled connections between numerous urban centers.

Like American greenways or European ecological networks, this project also consulted the public and stakeholders for inclusion of local interests. As a country with a rich historical linear infrastructure, this project exemplifies the significance of revitalizing existing potential for greenways. Overall this project reflects the approach to greenways found throughout the Europe, following the ecological network approach developed and initiated in the Netherlands and Germany (Toccolini et al., 2006).

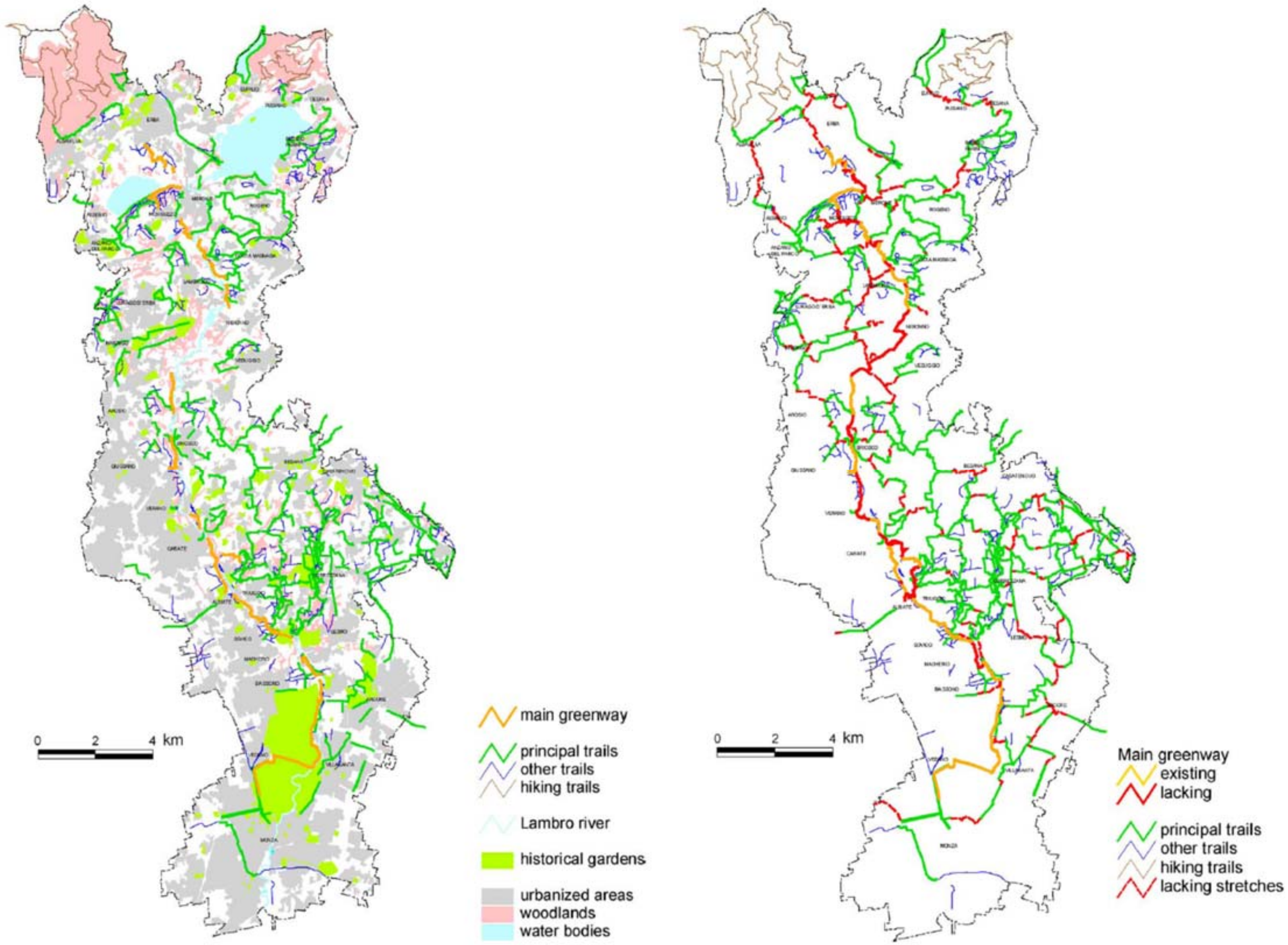

Figure 2.12. Existing green network (left) and the greenway plan (right) of Lambro River Valley Greenways System
Source: Toccolini et al. (2006)

2.7.4.4. An ecological network approach to conservation and natural connection for the City of Edmonton, Canada

An ecological network was introduced to the city of Edmonton as an additional strategic plan for a city with a long standing green tradition (Spencer Environmental Management Services, 2009). The idea was in line with existing initiatives for connecting green areas of the city. The ecological network was to support the focus on strengthening connection between natural areas which accommodated natural processes, wildlife movements and biological functions.

The strategic plan was intended to conserve existing natural networks for ecology, through annual and long term resource allocation with the participation of partners and other associations. Consultation and dialogue between the public and the city is also an on-going and continuous process, along with progressive assessment of the improvement efforts. This is a plan which sees all natural areas as one integrated conservation system. Consequently, planning, implementation and management are multi-sectorial and must accommodate the plans of the various institutions involved (Spencer Environmental Management Services, 2009).

Figure 2.13. Corridors along streams, connecting natural areas across agricultural fields
(Source: Spencer Environmental Management Services (2009))

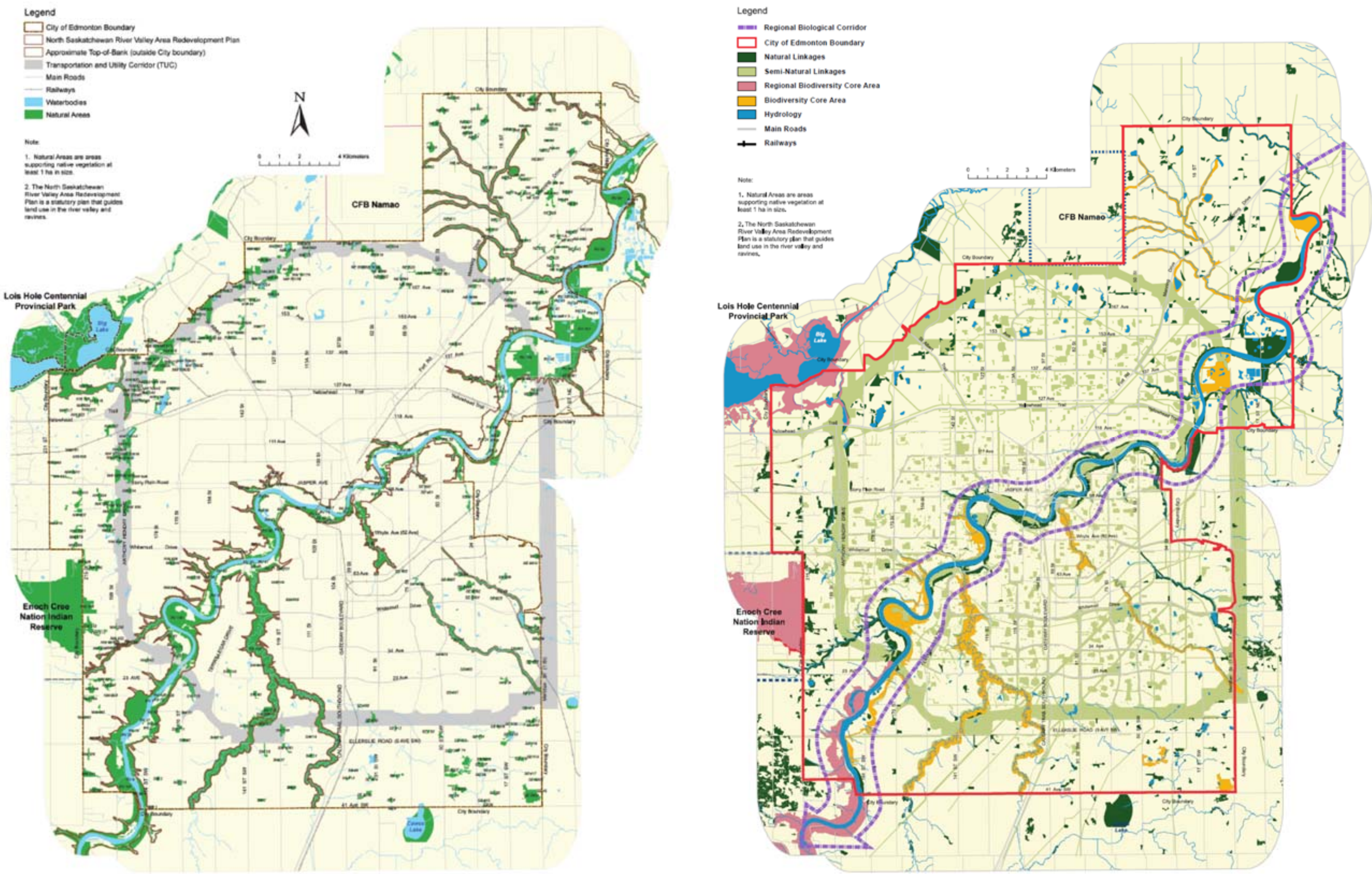

Figure 2.14. Existing natural areas (left) optimized into one connected system (right)
(Source: City of Edmonton Office of Biodiversity (2013))

As seen in Figure 2.14, both greenway and ecological network approaches were used by the city of Edmonton to optimize existing potential. Natural areas are understood as '*areas of land that are dominated by native vegetation in naturally occurring patterns*' and these are linked together within a single viable complex. The typical natural areas of the city are forests, grasslands, wetlands, riparian areas, lakes and rivers (Spencer Environmental Management Services, 2009).

2.7.4.5. Example from Asia and developing countries

Although greenways and ecological networks are not found in Asia to the same magnitude as in the USA and Europe, there are signs of acceptance and dissemination of the two concepts, as outlined below.

A case study of urban ecological networks in Tehran's metropolitan area

The Tehran case study is an assessment of how to apply landscape ecology principles to the planning of an ecological network for the city. The study is focused on the metropolitan area where urbanization has developed to the stage of becoming an alarming threat to the natural environment (Aminzadeh & Khansefid, 2010). This is a common phenomenon in the developing world.

As in the developed, in the developing world the aim of these networks is harmony between natural and physical systems in the city. The Tehran study started with identification of the existing natural and built features of the city to see what kind of intervention would best interweave these elements to increase ecological interactions. Options considered were an open space network, a park system, and green networks. A hydrological network was also believed to have powerful potential for the main corridor of the city, and this was assessed for significance as part of the method along with roads, which also have potential as green corridors.

This stage of the assessment was simply performed by overlaying three maps of aspects which are considered essential as part of a network. First is the map of farm land, open spaces and green spaces, both natural and man-made. Second is the hydrological map, and the final map is the road networks. Overlaying these maps produced a map of existing ecological patches and corridors in the Tehran matrix, comprising natural and built elements (Figure 2.15).

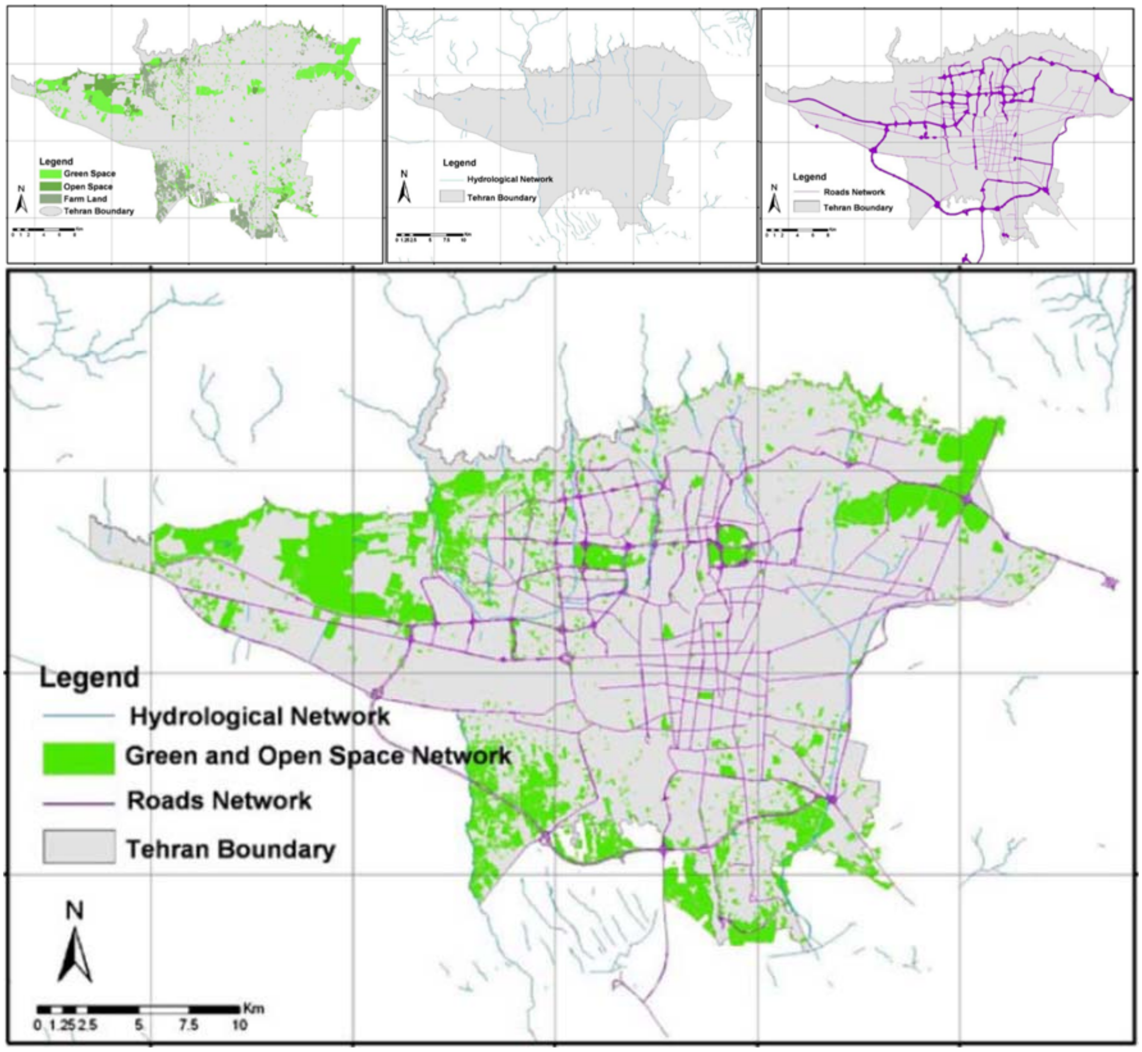

Figure 2.15. Ecological structure of Tehran (bottom) accommodating three important considerations: green areas (top left), hydrology (top middle) and road networks (top right) (Source: Aminzadeh & Khansefid (2010).

The final map of ecological structure is used to see how connections between existing spaces through existing water and road corridors could be made possible. This analysis is performed by considering the potential and restrictions for each element along with improvement suggestions in order to realize a viable urban green space network system for the city.

Singapore parks connector network

Singapore forms a good example on how a country with limited land area has managed to give priority to the provision of parks, open spaces and nature areas under the challenge of constricted land use and competition for economic development. The country started the green network initiative during the last decade (Tan, 2006).

The fact most green spaces in the country are artificial relates to the history of the land use shift experienced by the country. Massive development projects took place between 1960 and 1990 to deal with severe problems such as population growth, housing shortages and inadequate infrastructure. The growth of hard structures and construction led to extreme land clearance of natural areas such as forests, ridges, swamps, and the damming and canalization of natural rivers (Briffett, Sodhi, Yuen, & Kong, 2004). This unfortunately led to extinction of many taxa of butterflies, fish, birds and mammals (Brook, Sodhi, & Ng, 2003). In order to compensate for this 'loss' other forms of nature were constructed to fulfill the needs of the people, but without being able to return the lost biodiversity. This is one cause of the green spaces in the city being mainly for amenity value such as specially designed parks, road sides and median vegetation, open spaces with particular functions, and creepers over walls and pedestrian bridges (Briffett et al., 2004).

The greenway concept was adapted to link parks as linear corridors, and termed 'park connectors'. The Park Connector Network (PCN) is "*an island-wide network of linear open space that links up major parks and nature sites in Singapore, bringing people closer to these places and that enhances recreational opportunities for all*" (National Parks Board, 2008). The inclusion of parks and water bodies through the green and blue plans was designed as a long term project, which despite the start made to implement the connector network, will take about 30 years to complete (Sodhi, Briffett, Kong, & Yuen, 1999; Tan, 2006). Among the targets is to obtain 360 km of greenways and to achieve 0.8 hectares of parkland per 1000 residents (Tan, 2006).

In accordance with the National Parks Board of Singapore definition when the entire network has been completed two main objectives will be achieved from both human and biodiversity perspectives. People will be able to access parks, forming more cost-effective recreational opportunities. At the same time, biodiversity will be enhanced as a result of connectivity between refuge sites through nature corridors within the highly urbanized environment (Tan, 2006).

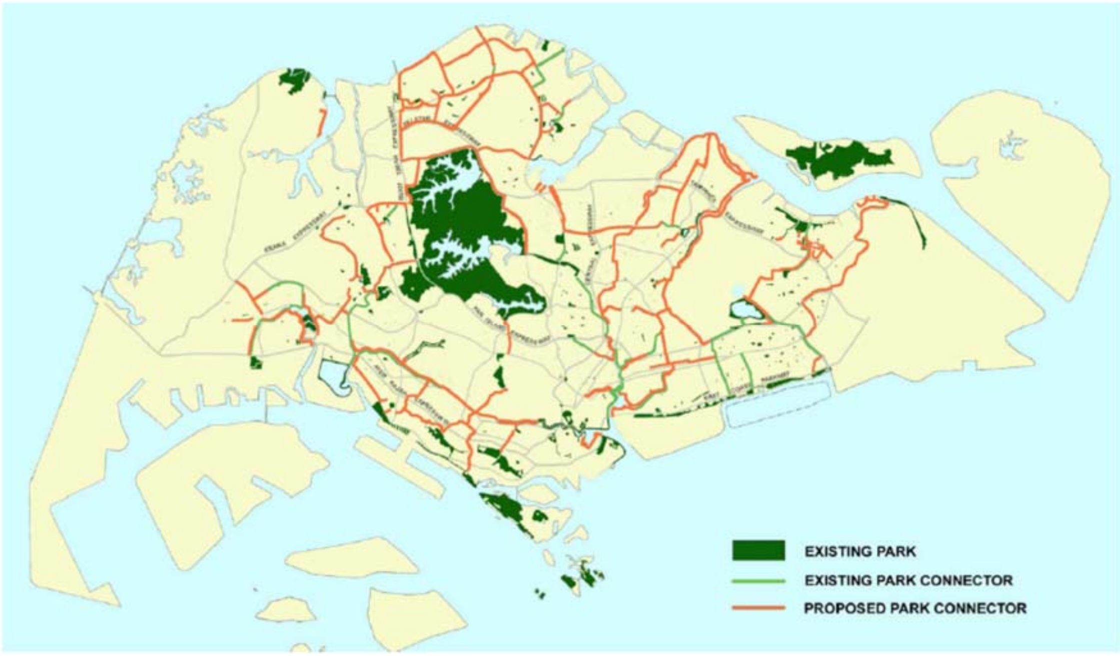

Figure 2.16. Park connector network, Singapore- a concept plan
(Source: Tan (2006))

Similar to other ecological project plans, collaboration between multi interests is important to gain support as well as to overcome criticism and problems. In order to deal with demanding pressures for direct economic gain from every inch of land, through a series of pilot projects the planners have made a coalition with key land-use agencies and local government leaders (Tan, 2006).

Figure 2.17. Example of a park connector within a highly urbanized environment (left) and a more natural backdrop (right) (Source: Tan (2006))

Apart from connection via corridors of trails and water systems, a proposal has also been made to utilize the railway as a green corridor throughout the country (Peng et al., 2010).

The Indonesian context

The two previous examples in Asia represent conditions not very like those of Indonesia. Additionally, there are applications of the network concept in other Asian countries but, like Singapore, they are more representative of the developed nation context, such as China and Japan (as in Yu, Li, & Li (2006); L. Zhang & Wang (2006) and Yokohari, Amemiya, & Amati (2006)). Otherwise examples from the developing world such as Iran (Aminzadeh & Khansefid, 2010) and Vietnam (Uy & Nakagoshi, 2007) are at the study and planning stage, and hence are more theoretical than practical. Therefore, to adapt the idea of inserting a greenway or ecological network into an Indonesian city, it is not sufficient simply to replicate implementation in other Asian cities. More studies are necessary to assess the applicability of these two ideas in Indonesian cities in order to comply with local conditions and requirements.

However, it is important to remember that Indonesia is a former Dutch colonized nation. As seen in many Indonesian cities, the Dutch heritage of providing green urban areas suggests that the ecological network concept could be implemented without starting it from scratch. An example is shown in the initiative for the conservation of a long area of mangroves in the city of Surabaya (ITS, 2010). The preservation of mangroves will create green coastal corridors which could be the target for connection with other forms of green areas in the centre of the city. Figure 2.18 shows the mangrove conservation project in Surabaya. As a first stage, this project started in the eastern coastal area of the city, being part of its open space system and the key to the formation of integrated parks, ponds and forest. Apart from nature preservation purposes, the area could also become an attractive recreational spot, which will give economic benefits to the local community.

Overall, there is a need to study Indonesian cities in both a deeper and specific way. As in other cities, this could be started by focusing on identifying existing potential as well as possible limitations and challenges.

Figure 2.18. Mangroves in Surabaya coastal area are to be preserved along the coastline to form a long, wide green patch. (Source: Housing and Human Settlements, ITS (2010)

2.8. Summary

This chapter described the problems of increased urbanization and the effect this has on urban green spaces. Often leaving them disconnected and of poor ecological quality. It continued by looking at examples of urban development in the developed world which have tried to ameliorate this problem but comprehensive planning of urban green spaces to link them in some form. Two clear ideas emerge. The first is the urban greenway, which originated in the USA, as a way of linking people to the more rural outskirts of the city through a series of connected parks and urban green spaces. The second originated in the Netherlands and has since been expanded to cross European boundaries. This is the ecological network which connects green spaces in the city such that they retain not just amenity value for human beings but also ecological value for other non-human species. These ecological networks, like greenways, connect urban areas with more natural and ecologically rich areas outside the urban development. Some examples of linked urban green spaces from Asia and developing countries were also considered. This review leads on to the research questions set out in the next chapter.

Chapter 3

Research Method, Plan and Stages

Chapter 2 discussed urban areas and their development, describing theoretical attributes, their positive and negative effects towards human beings and the environment, as well as efforts to tackle problems of urban development from the perspective and for the sake of people, nature, and the environment. From the discussion emerged the relationship between greenways and ecological networks as ways to create a better urban environment, as well as important aspects to consider prior to the implementation of such concepts. This requires understanding the condition of the urban area in question regarding potential and challenges, the process and its stages, and the supporting resources and information needed.

However, as mentioned before greenways and ecological networks were originally products of developed countries, and both approaches have many observable precedents in the developed world. Therefore, to understand whether implementation in a developing context might require a different approach, it is important to conduct more specific studies. Additionally, despite the presence of theoretical studies in Asia and the developing world, the differences between developing countries justify the need for specific local studies. Among the influential factors are culture and geographic conditions. Taking Singapore as an example, the city has limited functional options for green areas other than for human benefit and amenity value, due to the limited availability of space and resources. Applying all that has been implemented in this city would not be appropriate for Indonesian cities, which have much more land area available, and hence more options.

This research investigation is based in Makassar, a fast growing Indonesian city (see chapter 4). Because of its Dutch heritage there are some green areas in the city that were created by the Dutch (Chapter 4). However, like many other developing cities, these spaces are under pressure from development. One typical problem of the developing world is the need to provide more infrastructure for the fast growing population, a fact which has left little choice for local authorities but to expand the city, both inwards through densification, and outwards with consequent damage to surrounding green areas. Currently there is no evidence that green spaces are connected in this city, or that efforts to link them have ever been initiated. Whether they are or can be connected in a particular way in order to establish either a greenways, an ecological network, , or some other form of linked urban green spaces is also another question, and one which underlies this research.

3.1. Preliminary assumptions about Makassar

A more comprehensive overview of Makassar is presented in Chapter 4. As in most Indonesian cities, sprawling development is taking place in this city along with the inability of local government to assure provision of appropriate green spaces in accordance with prescribed regulation (Hidayansyah, 2007). This has resulted in green spaces that are not in the best condition to provide optimum benefits, and where there is often uncertainty regarding their future state and utilization.

Understanding the significance of natural features within the urban environment has been scientifically confirmed by many researchers (see Chapter 2). It is also important to see these attributes within the context of Makassar. With the current state and status of Makassar, there are spaces allocated for human amenity but fewer natural spaces that can serve a more comprehensive ecological function. Therefore, it seems in the Makassar context it is first important to perform a proper inventory of the real current condition of its non-built spaces. The existence of these features needs to be mapped, assessed for their intrinsic quality, and for possible connections between spaces. This will reveal the potential of the spaces in the city which could then be linked together in some form of network.

Habitat availability is part of any ecological network (R. H. G. Jongman et al., 2007). In order to assess habitat availability, it is necessary to identify plants and trees as the main components of an ecosystem. Therefore observing the biodiversity of plants is important. In other words, to assess whether an ecological network in Makassar is a possibility the first stage is to investigate the patches and corridors that exist within its urban regions by assessing their quality in terms of their vegetation as the basic content of a habitat.

When ecological quality cannot be achieved in local sites, then the inclusion of other linked sites may help to maintain biodiversity by enlarging the possibilities for habitats

(Opdam et al., 2006). Therefore it is also important to extend the investigation to the adjacent regions into a network that could have ecological quality. The opportunity for the inclusion of adjacent regencies is in accordance with long term government planning.

3.2. Research questions and objectives

Realising the importance of a full understanding of local circumstance before a greenway or ecological network concept can be applied to Indonesian cities, such as Makassar, this research is triggered by one main question:

"Can a greenway or an ecological network be accommodated in a city in a developing country?"

At first sight, because Indonesia was once a Dutch colony, it might be that the European ecological network would be more appropriate for Indonesian cities, as well as other developing countries which are former European colonies. However, modern cities in developing countries are much larger, and generally growing much more quickly, than their colonial origins. Consequently, this research will attempt to understand what sort of network of green urban spaces could be most appropriate for a city like Makassar.

The main question generates a number of sub-questions, as set out below:

- Are there existing patches and corridors?
- What is their condition?
- How could their condition and quality be assessed based on the resources available?
- If existing spaces are not appropriate for an ecological network, could they be improved, and if so, how?
- In terms of open space how does the city link up with its adjacent areas?

In order to answer the questions, this research has three main aims:

1. An investigation of the current spaces, both patches and corridors, by making an inventory of all available spaces in the city
2. Noting the current condition of all spaces in the inventory, including attributes that might affect the use and management of the space
3. Finding ways to evaluate spaces for connecting them into a network.

The process of finding answers to the main research question produces the following research objectives:

- To assess the current components of the landscape structure of the Makassar urban region, in order to see the potential for an ecological network for Makassar as a metropolitan area.
- To propose a framework for ecological network establishment based on existing or improved spaces for the Makassar metropolitan area.

3.3. Research stages

This research consists of 4 main stages as illustrated in Figure 3.1. A brief description of the research stages is presented in the following sub-sections.

3.3.1. Existing spaces inventory

The existing spaces inventory is basically identification of all green spaces in the city and the surrounding area. A detailed inventory will be made in the main city using GIS and aerial photographs retrieved from Google Earth dated 2010. To ensure consistency and clarity, aerial photos at altitude 500m will be used for all space inventory works. All spaces in the form of patches and corridors will be identified and their attributes recorded based on information from existing land-use maps, in local documents and assumptions based on local knowledge.

This stage should produce a mapped inventory of open and green spaces which will be used to develop a typology of the spaces. This stage is presented in detail in Chapter 5.

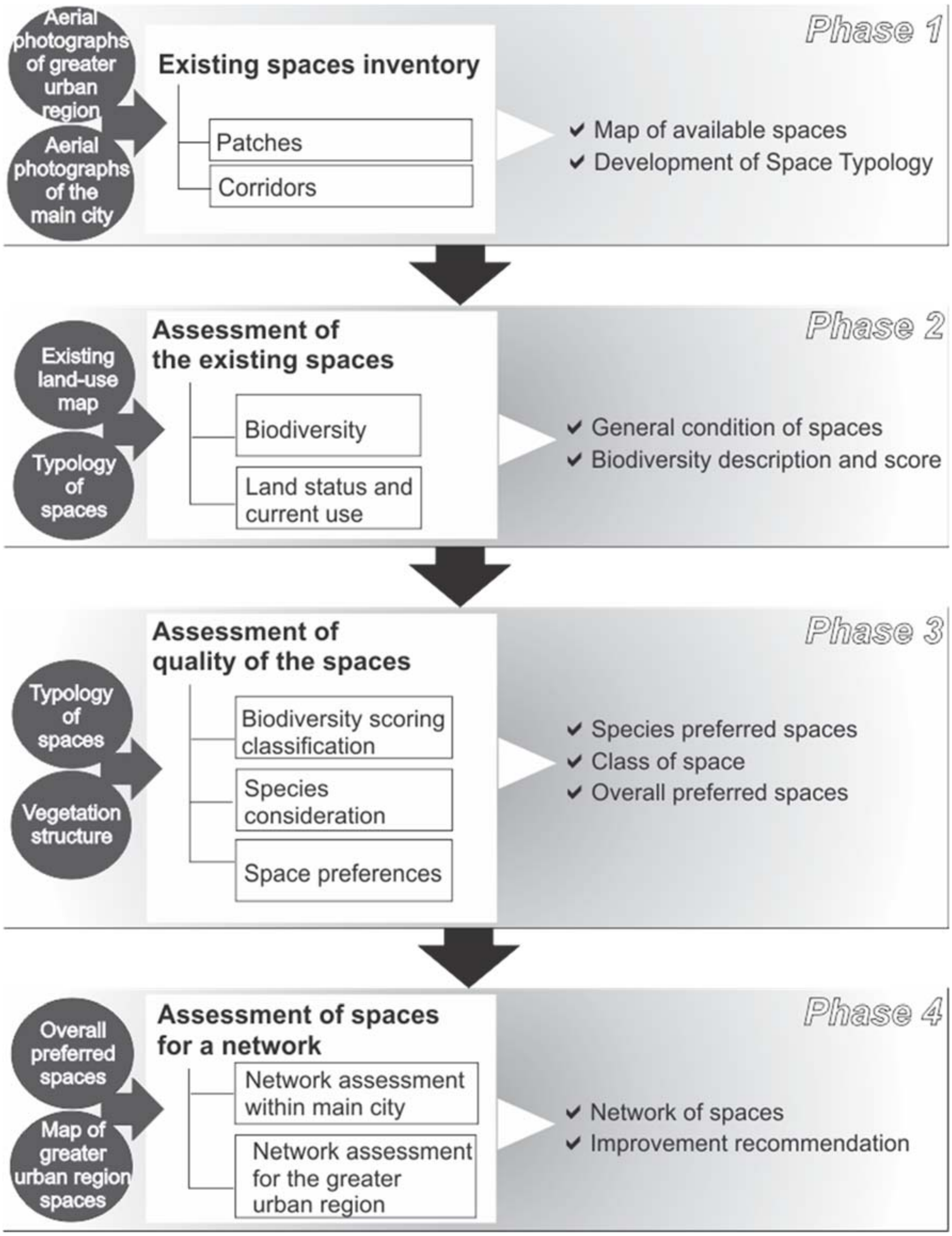

Figure 3.1. Research stages

3.3.2. Assessment of existing spaces

Using the typology of spaces as the basis for sampling, assessment of the spaces for their ecological quality and potential for being a habitat in the city will be undertaken. The main parameter for this assessment is biodiversity of vegetation using a rapid assessment method, the Rapid Biodiversity Assessment (RBA) developed for the UK but adjusted to suit the conditions of Makassar. The reasoning behind this decision as well as detail about the technical application of the assessment method is explained in Chapter 6.

In addition to biodiversity, information from the existing map of land use as well as from previous studies of green spaces in Makassar, including land status, use and ownership, will be used for a final assessment of existing spaces and how they might be connected.

3.3.3. Assessment of the quality of spaces

Plant biodiversity is one parameter in determining the quality of a space in terms of its feasibility as an ecological patch and part of an ecological network. The aim is to rank biodiversity based on three simple classifications: high medium and low. In addition a target urban species will also be investigated in order to rank the spaces in terms of species preferences. This ranking will then be consolidated with the plant biodiversity rankings, to produce an overall assessment of the spaces.

Taking land use and size of area into account in addition to the combined biodiversity score will produce a final classification of space (see Chapter 8). This will lead to proposing a table of the most preferred spaces for the city.

3.3.4. Assessment of spaces for a network

With the most preferred spaces produced in stage 3, the next step is to see the possibilities for linking these spaces into one or more connected systems within the main city of Makassar. Learning from previous studies on connectivity of spaces, this study will explore options for linking up these most preferred spaces. This includes consideration of increasing or reducing the quality of the network by referring to the class of spaces to be connected.

A network of spaces within the main city will not be viable without further extension to the more natural areas in the rural landscape outside it, therefore this study will also briefly analyse a possible network within the greater urban region, comprising three adjoining regencies which are officially included in the long term government spatial plan. The main target is to connect the most preferred spaces and network in the city with national parks and wildlife reserves located in the more natural landscapes not too far from it.

Apart from assessment of the spaces and the possible network, this study will also look at improvements that could be made in order to make spaces in the city have more value not only in terms of ecology but also for other functions that will support their inclusion into an integrated ecological concept for the city.

Table 3.1 summarizes the research stages.

Table 3.1. Research methods and stages

Stages		Scale/Scope of area	Components of assessment/analysis:	Resources/Tools	Obtained data/product
Phase 1: Existing Spaces Inventory					
Step 1	Identification of spaces	• Greater urban region • The main city	• Patches • Corridors	• Aerial photographs • Geographic Information System (GIS)	• Map of existing available spaces
Step 2	Development of space typology	Taking one sample district for detailed inventory and relating the results to a typology of all spaces in the city	• Patches • Corridors	• Aerial photographs • GIS	• Typology of space
Phase 2: Assessment of existing spaces					
Step 1	Identification of land status and current use	The main city	• Current use • Ownership • Other attributes	• Aerial photographs • Other related studies • Local knowledge • GIS	• Definition of land status, use and ownership • Other condition-related databases of the spaces
Step 2	Biodiversity assessment	Some sampling locations and spots in the main city	• Vegetation structure • Domin value • Vascular plants	• Rapid Biodiversity Assessment (RBA) • Field survey	• Biodiversity score • Vegetation structure • List of vascular plants

Table 3.1. Continued

Phase 3: Assessment on the quality of spaces					
Step 1	Scoring classification	Identified spaces of the city based on typology	• Biodiversity score	• Microsoft excel	• Biodiversity level
Step 2	Urban species consideration	Identified spaces of the city based on typology	• Vegetation structure • Domin value	• Microsoft excel • GIS	• Spaces of urban species preference
Step 3	Determining space preferences	Identified spaces of the city based on typology	• Biodiversity level • Land status and ownership • Space size	• USDA guidelines • Definition of land status, use and ownership	• Class of space
Step 4	Determining the most preferred spaces	Identified spaces of the city based on typology	• Spaces of urban species preference • Class of space	• GIS	• Most preferred spaces
Phase 4: Assessment of spaces for a network					
Step 1	Network analysis for the main city	Identified spaces of the city based on typology	• Large single or group of patches • Patches as stepping stones • Linear continuous corridors	• Previous studies on connectivity • GIS	• Network options for the main city
Step 2	Network analysis for the greater urban region	Identified spaces in the greater urban region based on land-use	• Main target patches (wildlife reserves) • Features leading to the target patches • Features in between the target patches and main city	• GIS	• Possible network of spaces in greater urban region
Step 3	Suggestions for improvement	All typologies of space	• Practice (technical aspects) • Management	• Previous studies • Examples from other places	• Recommendations for improvement

3.4. Summary

This chapter presents the methods and stages of the proposed research. It sets out the main research question and the sub-questions that emanate from this. It also explains the four stages of the research and the tools that will be used for these and indicates where more detailed information regarding these stages is found in the thesis.

Chapter 4

Overview of Makassar, the Study Location

4.1. Geographical location

Makassar is the capital of South Sulawesi Province, Republic of Indonesia. Located on west coast of Sulawesi Island, the geographical location of the city is 119°18'27.97" to 119°32'31.03" east and 5°00'30.18" to 5°14'6.49" south. Covering an area of 175.77km^2 (17,577 hectares) with considerable continuing development, this city has become the biggest in the eastern part of Indonesia. Makassar also lies in a strategic location for traffic from south to north within Sulawesi Island and between the western and eastern parts of Indonesia, as well as that from north to south of Indonesia.

Makassar borders several regencies. The southern border abuts the regencies of Takalar and Gowa, the north and east border abuts Maros and, as seen in Figure 4.2, west of Makassar is the Makassar Strait. There are 14 districts and 143 sub districts in Makassar. It is a coastal city, generally flat, with a slope of 5-0 degrees to the west. Most of the city lies 0–22m above sea level, with the topography rising up to the highland outside Makassar, with its areas of natural preserved landscape and national parks. This part of the landscape of Makassar is characterized by Mount Lompobattang which is flanked by the city's two main rivers: the Tallo river, which empties to the north, and the Jeneberang River which empties to the south of the city.

Table 4.1. Rivers that flow through the city of Makassar

No.	River Name	Length (km)	Width (m)		Depth (m)	Water flow (m^3/s)	
			Surface	Bottom		Maximum	Minimum
1	Tallo	90	10	5	3	143.7	2.5
2	Jeneberang	78.75	75	20	10	150	2.5

Source: BPDAS (River-shed Management Agency) (Makassar City Council, 2010)

The geographical position of Makassar in Indonesia and in Sulawesi can be seen in Figure 4.2. The short description above along with the map shows the strategic geographical importance of Makassar in terms of economic and political interests. Makassar has become a node for product distribution from different parts of Indonesia. Its position gives the city a comparative advantage among other cities and regions in eastern Indonesia (Makassar City Council, 2009a). This explains the rapid development of the city and the integration of the other three proximate regencies into a greater urban region known as the 'Mamminasata' (See Chapter 4.6.) integrated area development (Figure 4.2.d). With its strategic location, Makassar airport has become very busy. As well as being the gateway to eastern Indonesia, it is Mamminasata's only international airport. A study by Japan International Cooperation Agency (JICA) on Mamminasata recognized the significant position of Makassar as the center of Mamminasata greater urban region (Figure 4.1.)

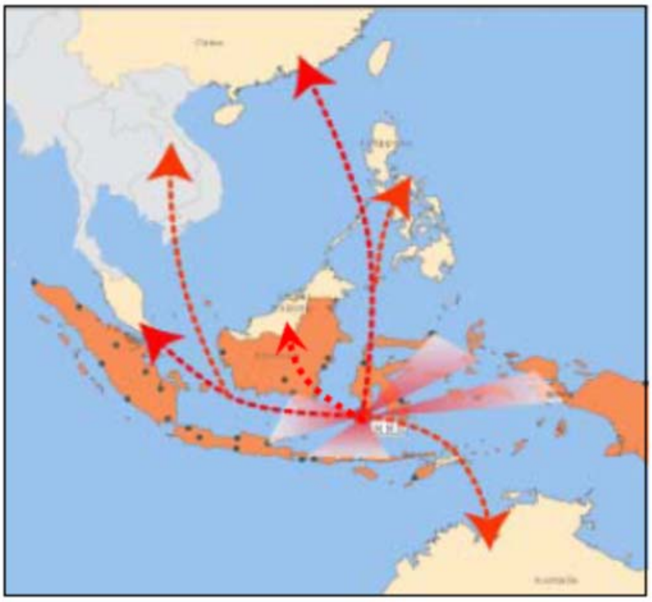

Figure 4.1. Illustration of the strategic position and value of Makassar in terms of domestic and global transport and trade
(Source: JICA study (Ministry of Public Works, Mamminasata Metropolitan Coordination Board, & Japan International Cooperation Agency, 2006))

In consequence and as one of biggest province in Eastern Indonesia, South Sulawesi has experienced growth and development in almost all aspects. As a result, the ratio of urban green spaces to population has become smaller. Likewise, as the biggest city in Eastern Indonesia and the capital of South Sulawesi, Makassar has experienced deterioration in the quantity of urban green space due to population growth which results in high demand for land use conversion (Amin & Amri, n.d.). A local newspaper (Tribun Timur, August 6th 2009) reported the latest JICA study reveals that open space in Makassar remains less than 4% of total area (Ministry of Public Works et al., 2006), far lower than the minimum 30% as stated in the Regulation of the Minister of Public Works No. 05/PRT/M (2008).

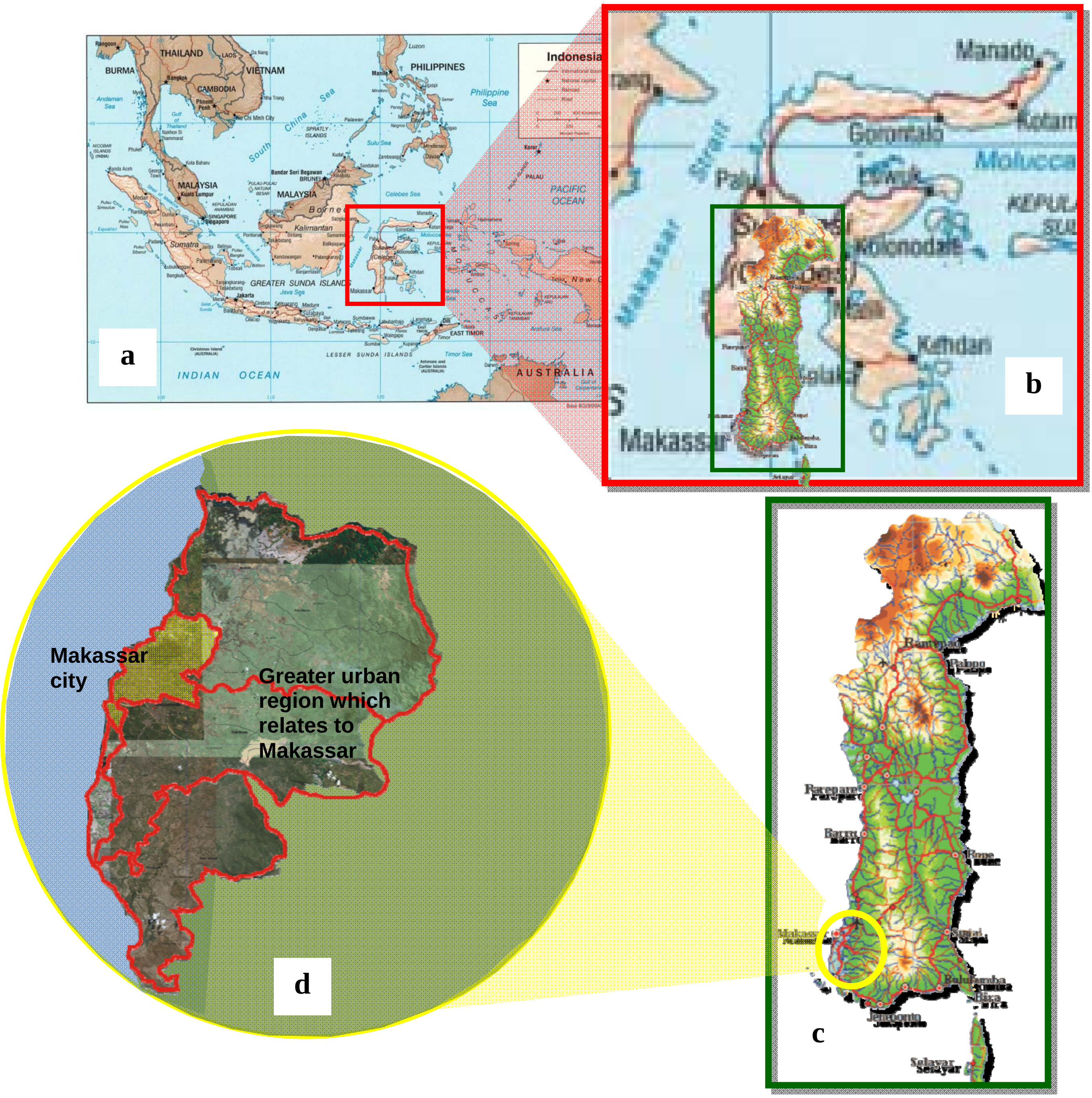

Figure 4.2. Study location; a) Indonesia, b) Sulawesi (Celebes) Island, c) South Sulawesi Province, d) Makassar and its surrounding regions

(Source: www.geografersion.co.nz (2012); www.forumms.com (2013); with modification)

4.2. Brief history of Makassar

The brief history of this city is based on the official website of Makassar City Council plus additional sources as indicated. Makassar started as a small trade port on the estuary of the River Tallo in the fifteenth century. This small trade port was under the control of the Siang kingdom, which was based around Pangkajene, an adjoining small area to the north of Makassar, which is now a neighbouring regency. The small Tallo authority then merged with the other small kingdom of Gowa, and later declared independence from the Siang Kingdom. They further expanded their territory by invading the surrounding kingdoms. As the kingdom expanded, Tallo port became busier, causing siltation of the Tallo River which forced the relocation of the main port to the estuary of the Jeneberang River. Afterwards, the powerful development of the Tallo and Gowa collaboration gained further momentum through the construction of Somba Opu port, which over the next 100 years became the main zone of Makassar.

The official anniversary of Makassar was declared following the first congregation Friday prayer performed in the Tallo Mosque on November 9th 1607, not long after Islamic influence from Sumatra converted the Kings of both Tallo and Gowa to Islam. It took just a century for Makassar to evolve into a prominent trading city with more than 100,000 inhabitants.

During the Dutch colonization, strong resistance was given by the Gowa kingdom to the Dutch. It took a three year military operation by the Dutch with their collaborators from Ternate, Buton and Maluku until in 1669 the most devastating and fierce battle left Makassar and its biggest port Somba Opu conquered. The battle caused immense destruction of the city. In 1673 the Dutch redesigned the city, calling the main part 'Fort Rotterdam' and the areas surrounding it 'Vlaardingen', although the size of the new city was much smaller than the previous Makassar. This redesign made way for the Dutch style in buildings, city layouts and parks. The historic Dutch use of green open spaces in the city forms a link with the modern the Dutch use of ecological networks.

Figure 4.3. 'Fort Rotterdam' the centre of Makassar in early 19 C.
(Source: Makassar City Council (2009c))

In the early 20th century, the Dutch finally completely conquered all other independent regions in Sulawesi, and Makassar was declared the centre of Dutch governance in East Indonesia. After this conquest, the Dutch had full control and there were no more uprisings. This situation boosted economic growth, the population increased threefold and Makassar became the second biggest city outside Java.

The Second World War and Indonesian independence once again changed Makassar. People from the surrounding regions as well as from other parts of Indonesia swarmed to Makassar, causing the population to increase dramatically from around 90,000 to more than 400,000 people between1930 and 1961. Because 'Makassar' is also the name of an ethnic group originating from Sulawesi, and due to the multi-ethnicity and multi-cultural development in Makassar, in 1971 the name of the city was changed to 'Ujung Pandang'. The new name comes from the word 'Jumpandang' a nickname which was closely associated with the city during the kingdom period. The city name was finally restored back to 'Makassar' in 1999. The total area of the city was also officially updated by adding about 6.4 km towards the sea, making it 175.77 km^2.

The influence of colonization in Makassar can be observed through its Dutch heritage. Some structures have been demolished due to development of the city, yet some old buildings, including the main fortress (Fort Rotterdam), now known as 'Benteng Ujung Pandang', and transport infrastructure are still intact although some rejuvenation has also been undertaken. The Dutch also started the establishment of railways in Makassar but when the Japanese took over the city about three years before Indonesian independence, the first railway line from Makassar to Takalar was demolished and the railway initiative never progressed (Gassing, 2012). This means there are no railway corridors in Makassar.

Figure 4.4. Fort Rotterdam, present day (Source: Google earth, 2010)

Figure 4.5. Railway line initiated by the Dutch but later demolished by the Japanese
(Source: KITLV Leiden <u>in</u> Gassing (2012))

Regarding urban green space, almost all the main public parks and green space in Makassar are in fact Dutch heritage, such as Taman Macan Park and Karebosi, which is considered an important landmark of Makassar (Hafiruddin, 2012).

Figure 4.6. Dutch green initiatives in Makassar:
Karebosi public field (left) and Sudirman Street (right), one of the main streets in Makassar
(Source: KITLV Leiden in Gassing (2012))

Apart from leaving green parks, traces of Dutch green heritage are also seen in road corridors. Originally all main roads were kept green with rows of big trees. Unfortunately due to road expansion, some trees have been cut down and the present main roads in Makassar are not as green as they were. Consequently, trying to establish greenways or an ecological network as found in some developed countries into the city will not be something completely new. The foundations of such an approach as introduced by the Dutch can be found in their other occupied cities in Indonesia, such as Bogor with its great national park and Bandung, both of which are in Java. Furthermore, Chinese cities have also used the greenway concept for thousands of years, in addition to using its modern adaptation from the western world (Yu et al., 2006). The local wisdom of people in Sulawesi living together with the environment has also been something acknowledged and well-studied (Mulyadi, 2009).

Figure 4.7. Taman Macan, a public park, heritage of Dutch Colonization

4.3. Biophysical and landscape character of the city

In 2010 the climate station of Paotere in Makassar recorded the average monthly temperatures of Makassar as lying between 26.5-28.5ºC. Average humidity is 82.7% with average wind velocity 4.0 knots. Monthly rainfall in Makassar recorded in the same year ranged from 56.7 mm to 869.4mm with a total 243 rainy days. December and January were the months with the highest rainfall and most rainy days, while July and August were the driest months (Makassar Statistic Board, 2012).

Soil types in Makassar consist of inceptisol and ultisol. In almost all parts of Makassar the soil type is inceptisol, which is found in areas around rivers, swamps, and the alluvial plain, as well as in the slightly hilly areas (Makassar City Council, 2009a).

Cook (2002) classified patches and corridors into two main categories: natural and cultural. Natural refers to areas whose function is essentially a process of existing in or produced by nature (rather than by the intervention of human beings), that do not involve human activities, or are not dependent on human values. The specific character of this type is the absence of human impact and fewer unnatural conditions of change (such as soil compaction, or existence of exotic species). The cultural refers to areas which have been influenced by human activities and whose value has been determined by human effort and force. A cultural patch might still carry value in nature but its main function is characterized by human involvement. An agricultural field is an example of a cultural patch. The absence of indigenous species is another aspect that lessens the ecological value of an urban green space. .

Makassar in general is lacking in natural features. The only natural patches that still exist are the masses of Nypa palm alongside the River Tallo, the main river that runs across Makassar from east to northwest. Even these patches have been severely encroached on and thus fragmented by cultural activities, mainly agriculture fields and fish ponds. Some settlements have also been moving towards the river. Because these patches at times run linearly alongside the river, they form a type of discontinued corridor. If later these linear patches are classified as corridors they would be the only natural corridors remaining in Makassar. The cultural patches that exist are mainly for food production such as paddy fields, mix-crop fields, and fishponds.

When assessing the landscape ecology principles in Makassar using the patch types of Dramstad, Olson, & Forman (1996), who classified patches based on their origin, it is observable that the city of Makassar is dominated by the 'introduced' type of patches. Falling into this category are all built parks, corridors, farms, and fishponds. The other types available are 'remnants' (bulk of nypa palms along the sides of the main river) and 'resources' (some wetlands in the city).

Figure 4.8. Cultural patches of fishponds and agricultural fields claim natural patches alongside the River Tallo, leaving small remnants of mass of nypa palm and natural river corridors. (Source: Google earth, 2010)

 

Figure 4.9. Vegetation in estuary (left) and mass of nypa palm alongside the main river form the most natural features still found in Makassar
(Source: Sebastian (2010))

Apart from food production activities, and similar to many other cities in Indonesia, the growth of the city is causing changes which have implications for the physical condition of land including the natural environment of the city (Hidayansyah, 2007).

Table 4.2. Land use in Makassar showing the main field characteristics

District	Area (Hectares)						
	Built area including yards	Paddy field	Mix crop field (including fishponds)	Plantation	Forest	Others	Total
Biringkanaya	2,789	657	284			1,092	4,822
Bontoala	110					100	210
Makassar	210					42	252
Mamajang	135					90	225
Manggala	366	827	411			810	2,414
Mariso	125					57	182
Panakkukang	382	2				1,321	1,705
Rappocini	267	20				636	923
Tallo	202	15	10		165	191	583
Tamalanrea	1,151	632	196		61	1,144	3,184
Tamalate	916	547	115			443	2,021
Ujung Pandang	145					118	263
Ujung Tanah	427					167	594
Wajo	118					81	199
Total	7,343	2,700	1,016	0	226	6,292	**17,577**

Source: Report on the state of environment (Makassar City Council, 2010)

Table 4.2. suggests the general types of land-use which could be related to Cook's classification (Cook, 2002) of natural and cultural areas. It appears that Makassar is indeed lacking in natural areas. The forest areas in two districts as shown in the table are

designated urban forests, namely the campus ground of Hasasnuddin University in the district of Tamalanrea and the conservation area of Lakkang which forms one part of the river corridor in the district of Tallo. Neither are natural forests.

It is interesting to note that the local authority acknowledges the lack of available spaces belonging to the state, and hence the public. Therefore, they prefer to classify land use based on criteria related to psychological visualization, thus describing land use in the form of zone typology, rather than classifying areas in the traditional way based on visual observation of empty, vegetated, or built space. Therefore, it seems that according to lithology, topography, soil types, climate and types of vegetation, the council can recommended that all areas in Makassar are developed for cultural activities as no areas meet the required criteria for their preservation (Makassar City Council, 2009a). This apparently pessimistic statement might suggest that the lack of natural features in Makassar means it is not a challenge for the city to witness the development of cultural patches, even when these claim what remains of the natural areas. However, this study considers it important to investigate the potential of spaces in the city, both cultural and natural spots, and hence an inventory will be made and a typology developed in a more traditional way.

4.4. Demographic aspects and development

Makassar is divided into 14 administrative districts. Each district also consists of various numbers of sub districts, making a total of 143 sub districts. The size of a district does not relate to its number of sub districts. The district of Tallo has more sub districts than others while its size is not the largest (Table 4.3).

Table 4.3. Sub districts and their population

District	Makassar area based on Study Map (Hectares)	Makassar area based on Government Data (Hectares)*	Number of Sub districts*	Population (2010)*
Biringkanaya	3,163.81	4,822.00	7	167,741
Bontoala	147.58	210.00	12	54,197
Makassar	251.06	252.00	14	81,700
Mamajang	241.48	225.00	13	58,998
Manggala	2,302.23	2,414.00	6	117,075
Mariso	228.44	182.00	9	55,875
Panakkukang	1,414.17	1,705.00	11	141,382
Rappocini	1,207.32	923.00	10	151,091
Tallo	903.40	583.00	15	134,294
Tamalanrea	4,312.68	3,184.00	6	103,192
Tamalate	2,627.40	2,021.00	10	170,878
Ujung Pandang	282.64	263.00	10	26,904
Ujung Tanah	189.70	594.00	12	46,688
Wajo	204.11	199.00	8	29,359
Grand Total	**17,476.01**	**17,577.00**	**143**	**1,339,374**

Source: * Makassar Statistic Board (2012)

Table 4.3. has two columns for the area of each district. One is generated from the area mapped in this study where the district borders are based on the mapping of the greater urban region of Mamminasata (Ministry of Public Works et al., 2006). The other area column is government data (Makassar Statistic Board, 2012). It can be seen the area recognized by government in some districts is larger, some being significantly greater than the area generated from the map. It is understood that the government data includes all administrative borders including some small islands such as Lumu-lumu, Baranglompo and Barangcaddi. These islands are part of the district of Ujung Tanah. This increases the district size, whereas this study will not include the islands around Makassar. Apart from these island areas, the coastal areas up to four miles (6.4 km) off shore, which are also in the government total area, are excluded from the study coverage area. The areas of the Makassar districts according to the map are in line with the official Mamminasata districts according to Presidential decree No. 55 (2011). On the other hand, some study district areas are larger than government figures due to different interpretations of the district border, especially that between the districts of Biringkanaya and Tamalanrea.

The final areas of Makassar and its districts which are used in this study are shown in Figure 4.10.

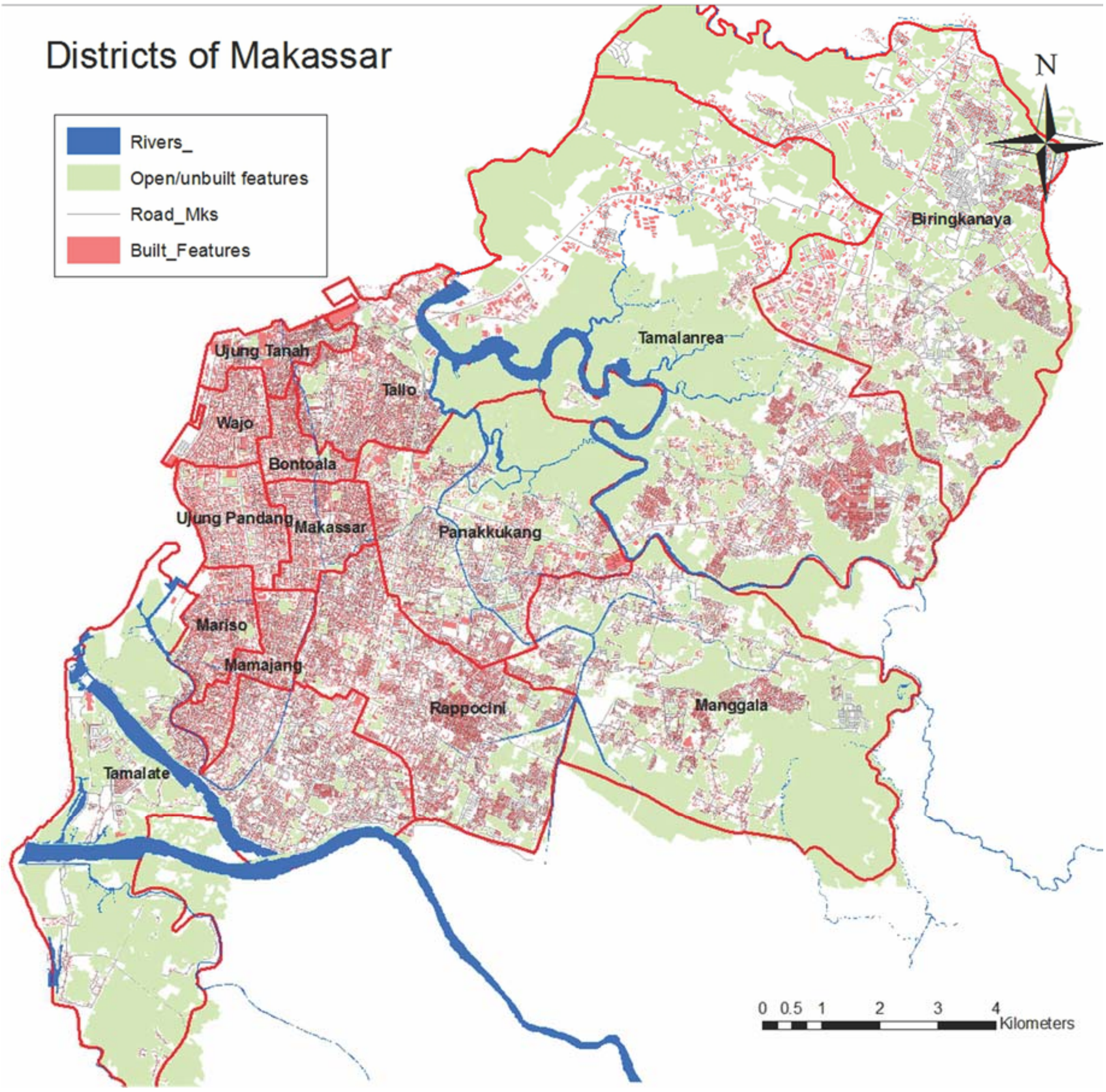

Figure 4.10. Makassar area excluding small islands and 4 mile off shore zone

Makassar has an average population density of 6,200 people/km^2. There are 5 districts with a population density of over 20,000 people/km^2. The district of Makassar is the densest, with over 32,000 people/km^2. Demographics are an important parameter in evaluating the sufficiency of green space in a city. Equality of green space provision based on population numbers as well as other demographic variables, such as income, could be used as an indicator for environmental improvement in an urban area. These aspects are discussed in Chapter 10.

The fact that Makassar is a big city with better infrastructure, education institutions, industries and other facilities than other cities in this area of Indonesia has made it attractive for people from the adjacent regencies. They come for various reasons, mostly economic, making the population and urbanization in Makassar increase along with the development of the city. Similar conditions occur in Jakarta, which is the main city for the people of its adjacent regions, and is where people come hoping for a better life. The increase in population in Makassar has been as high as 20,000/year, giving a sense of the potentially alarming population growth in this city. The birth rate contributes most to population growth which in 2010 reached 23% (Kamilia, 2010), but with a rising population comes urbanization and its associated problems. An urbanization indicator from 2012, revealed a high level of illegal residents of around 3000 people (Rakyat Sulsel Online, 2012).

Development which responds to population increase in the city has implications for the urban environment. A significant increase in motorized vehicles is a consequence of the population growth. The number of motorized vehicles has increased by 10-12%/year. With static or low growth of road infrastructure, traffic congestion has become a serious and ever present problem in Makassar (Makhyani, Hariyati, & Jinca, 2009).

As the city becomes more congested with vehicles, air pollution levels also increase. According to the regional environmental agency, Makassar has the most polluted air in South Sulawesi. The pollution is worse during busy business hours in concentrated activity spots such as main roads, business centres (CBD) and bus stations (South Sulawesi Environmental Agency, 2009).

Hidayansyah (2007, p. 82) has summarised problems that are starting to emerge in Makassar due to development and urbanization as follows:

1) a rather aggressive growth of shopping and business infrastructure;
2) development of slums;
3) imbalance in population densities across districts;
4) inappropriate land use beyond the intended use as regulated by regional planning documents;
5) traffic congestion;
6) and deteriorating air quality.

Pointing especially to the fourth problem, his study showed that by 2006, there have been violations of Makassar's spatial planning according to the 1984 document of RUTRW (General Design of Regional Spatial Planning) because development has taken place in inappropriate zones. Despite the spatial planning document being enforced by regional regulation, implementation on the ground has not reflected this. In fact both public and private green areas have been claimed for other uses and hence these have been declining in number over the years. Unless this unauthorized development has legal consequences, this should be a warning that there is the possibility the same transgressions will be repeated in the following years and planning stages (RUTRW 2010 – 2030). This situation occurs even though, according to a high official of the Indonesian Ministry of Public works, violation of spatial planning as regulated by legalized local documents could have serious legal implications for the regional government (Solihin, 2013).

One of the aims of this study is, therefore, to highlight the potential of available and prospective green spaces in the city. Hopefully this can provide useful information for better urban green space management in line with city growth and development.

4.5. Green spaces in the city

In Makassar, there are several parks spread throughout the city, however their role has not been yet optimized by residents for the reasons listed below:

(1) the distribution is not spread evenly, some areas (sub districts) are lacking in parks/gardens (Makassar City Council, 2009b);

(2) the proportion has not met the need of the city (Hidayansyah, 2007; Ministry of Public Works et al., 2006);

(3) there are accessibility issues in terms of location and authorization (Iswoyo, Vale, & Bryant, 2011);

(4) the parks have not been linked to optimize their roles when working together as a system (greenway) (Hidayansyah, 2007);

(5) and maintenance issues mean the parks do not meet requirements for their proper function (Mariana, 2006).

The fact that some areas in Makassar have not been developed according to their official designation in terms of regional spatial planning, might be the reason the regional parliament has meticulously and cautiously studied the city council proposal for the RUTRW Document for the 2010 – 2030 period. The draft is still under discussion and has not been approved despite people calling for its immediate implementation because of the need for development. The reason behind the delay according to the official parliamentary website is that points in the draft are not in line with some prescribed requirements, such as the minimum standard of green space for the city (Fajar Online, 2012). Consequently, the city council does not have the legal basis to put its spatial planning into action. This has caused the current spatial development direction in Makassar to be described as unclear and 'chaotic'. This situation leads to further 'violation' as development needs to proceed while not having legal guidance, causing more public spaces to be overtaken for commercial purposes (Anonymous, 2011).

Assuming the draft is approved without significant alterations, the spatial planning objective for Makassar city will be similar to that set out in the document of the previous period, and will focus on four targets. The first is to ensure prosperous, cultural and equitable development for the people. The second is to provide sustainable space utilization in line with natural carrying capacity, as well as being affordable for people and the government at regional and national level. The third is to achieve harmonious employment of both natural and artificial resources, considering human resources as the most important factor. The final target is to implement regulated space utilization for preserved and cultural areas (Makassar City Council, 2006).

The intention of ensuring spaces in the city are appropriately utilized according to their designation makes it possible to introduce a nature-friendly concept to the city, in terms of trying to improve and link together urban green spaces. The unfavorable experience of sprawling development in Makassar must be addressed in the next long term planning draft (RUTRW). Not only must the development and growth of the city be in line with official legal planning documents, but the orientation also needs to comply with other regulations and standards at national or even international level. This is particularly relevant in the campaign for Makassar to be both a green and world class city (Makassar City Council, 2012). Despite the pessimistic view that Makassar is nowhere near a world class city because of the deterioration in environmental quality (Yulanwar, 2011), the city mayor continuously outlines the efforts taken in order to make Makassar adhere to the requirements for being a city with good environmental quality. These include meeting the standards for urban green areas according to the city area and population. Progress towards meeting these standards can be assessed by looking at the current condition of the city, and the future program.

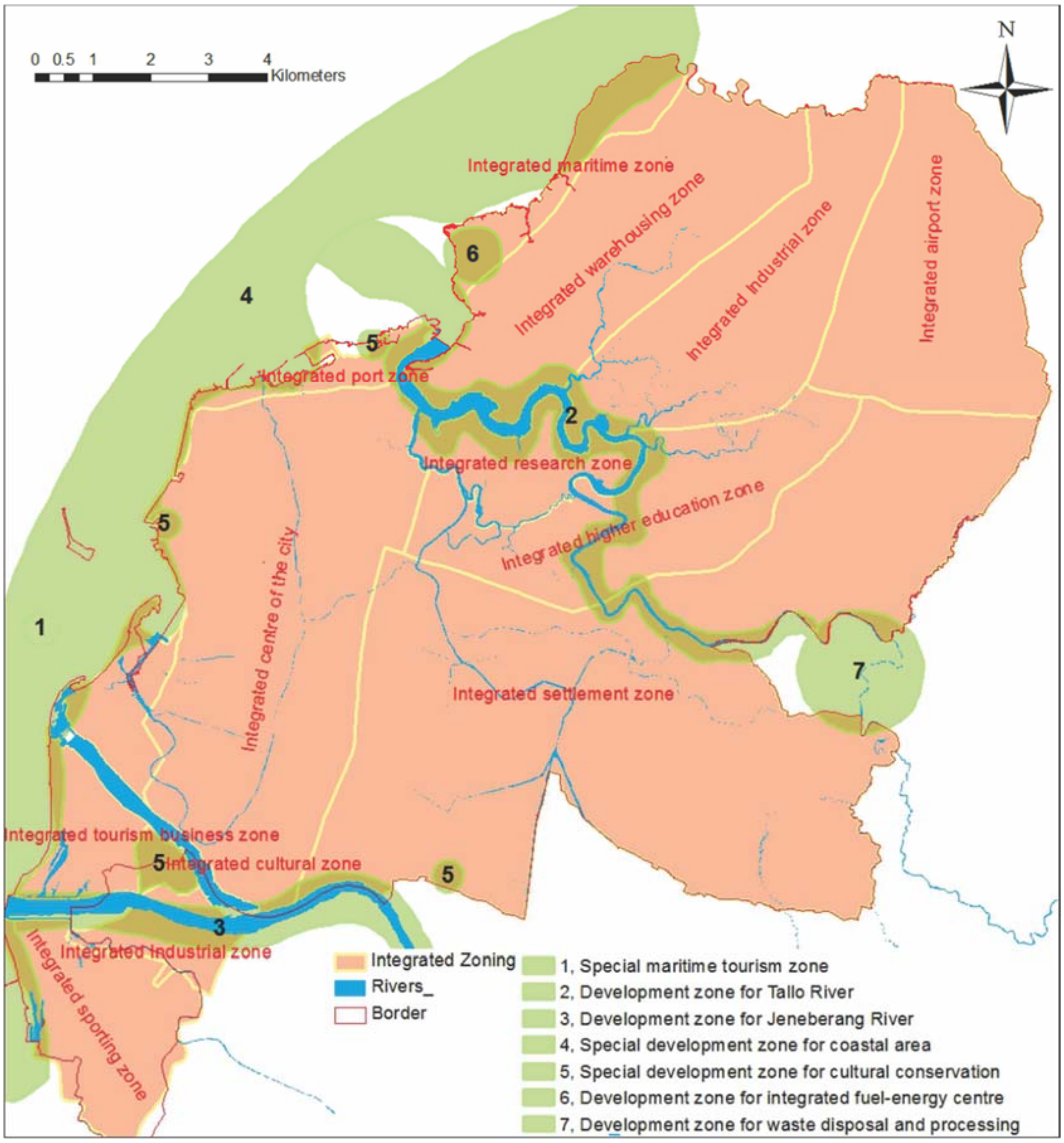

Figure 4.11. Integrated development zoning and special development areas according to Makassar Spatial planning 2016
(Source: Makassar City Council (2009b), re-digitized)

The spatial planning document elaborates directions for development in Makassar. The planning document basically divides the city into five general development zones before further classifying zones based on special and integrated development (Figure 4.11.).

Apart from development of areas with a focus on economic development, the city spatial plan also proposes green area development. This consists of six areas with set targets for proportions of green space (Figure 4.12.)

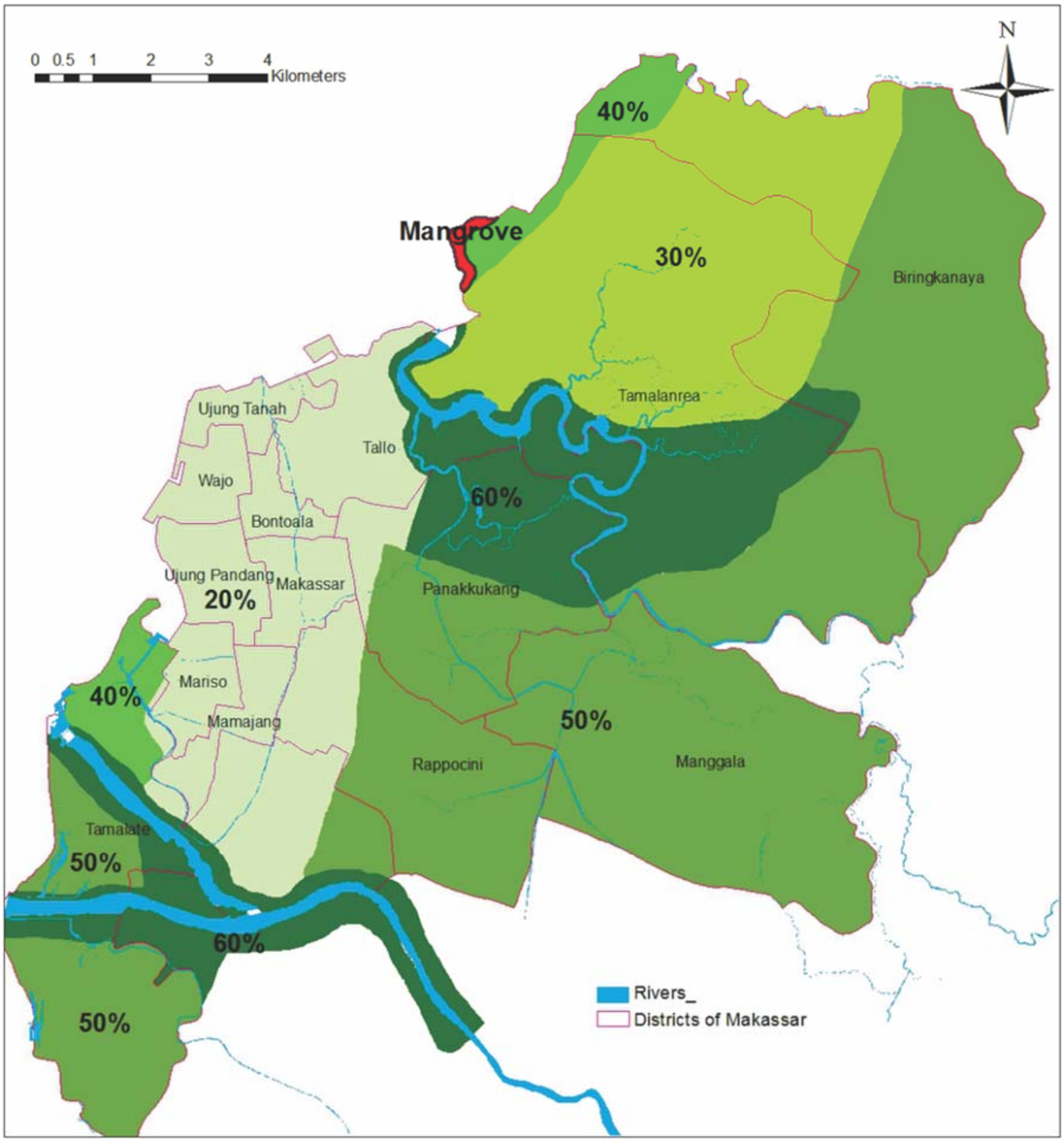

Figure 4.12. Green Development Plan 2016 for Makassar city.
(Source: Makassar City Council (2009b), re-digitized)

Areas around both main rivers are projected to be the greenest parts of the city, while the west central part of the city, where most activities and business take place, has the minimum proportion of green area (20%), which just complies with a standard set by the Ministry of Home Affairs (2007). There is confusion regarding this target as the text in the draft of General Design of Regional Spatial Planning 2010-2030 only mentions

5% as the target for green areas in this business and activities centre. This difference might have something to do both with the time frame and interpretation of what a green area is. The map in Figure 4.12. is re-drawn based on one in the city council official website. The legend indicates 2016 as the time when presumably the government is expecting to achieve the target. Yet, the same targets on the map are also included in the draft document for General Design of Regional Spatial Planning 2010-2030. Therefore, the exact target year is still uncertain. Because of its compliance with national recognized standards and regulation, this study considers the higher percentage (20%) as the minimum target in the most urbanized part of the city.

It is important to set the veridical time frame as the map raises further questions such as the extent to which the target is currently achieved and whether the city is on track to achieve the target, or even more pessimistically, whether the target is reasonable. However, these issues are beyond the scope of this thesis. Rather, observation of the identified spaces as outlined here should help those monitoring the level of achievement or progress. For this purpose, it is important to understand the available existing spaces as well as the potential spaces in order to meet the spatial target. It is also important to note whether the intentions to make Makassar city as green as the plan in Figure 4.12. cover all possible spaces, including non-public and non-state owned fields, or only those spaces that can be fully controlled and managed by the city council. If the latter, the plan for a green Makassar as in Figure 4.12. will remain an impossible dream.

Several types of green areas are mentioned in the draft of General Design of Regional Spatial Planning 2010-2030 (Anonymous, 2010), these being mangroves, public green facility, green corridors (assumed to be road and stream/river corridors), cemeteries, neighborhood gardens, public parks, house yards, plant nursery sites, industrial open space, campus grounds and other fields whose functions are similar. Although the document mostly considers public spaces some private areas are also included. However, most data and information regarding available open and green spaces as gathered from different sources only mention public spaces and areas which are managed and controlled by the government. They thus exclude private or corporate spaces that have great potential for adding to the green areas of the city.

Table 4.4. sets out the existing recognized green and open space in Makassar. It is based on the detailed inventory made in this study, which was then confirmed (Adhinugraha,

2010; Hidayansyah, 2007; Mariana, 2006) for the spaces that are officially acknowledged by the local government and which are therefore assumed to be under government control and management.

Table 4.4. Existing government recognized available green spaces in Makassar

District	District Area	Open/Green spaces area (Ha)	Percentage of open/green spaces coverage
Biringkanaya	3,163.81	186.14	5.88%
Bontoala	147.58	5.60	3.79%
Makassar	251.06	3.03	1.21%
Mamajang	241.48	6.85	2.84%
Manggala	2,302.23	78.01	3.39%
Mariso	228.44	7.05	3.09%
Panakkukang	1,414.17	201.76	14.27%
Rappocini	1,207.32	7.95	0.66%
Tallo	903.40	38.32	4.24%
Tamalanrea	4,312.68	285.73	6.63%
Tamalate	2,627.40	51.47	1.96%
Ujung Pandang	282.64	14.56	5.15%
Ujung Tanah	189.70	8.04	4.24%
Wajo	204.11	0.96	0.47%
City Grand Total	**17,476.01**	**895.48**	**5.12%**

Source: Mapping with interpretation using additional sources as mentioned

As seen in Table 4.4. according to official government interpretation and the inventory of green spaces in Makassar, only one district has over 10% (14.27%) which is still far below the minimum requirement or target of 20%. Clearly from this, only depending on state land, public space and other government managed areas will not make Makassar a green city. In fact the local government has mapped all land uses in the city which they could use as a base to determine which other types of space are available, as seen in Figure 4.13.

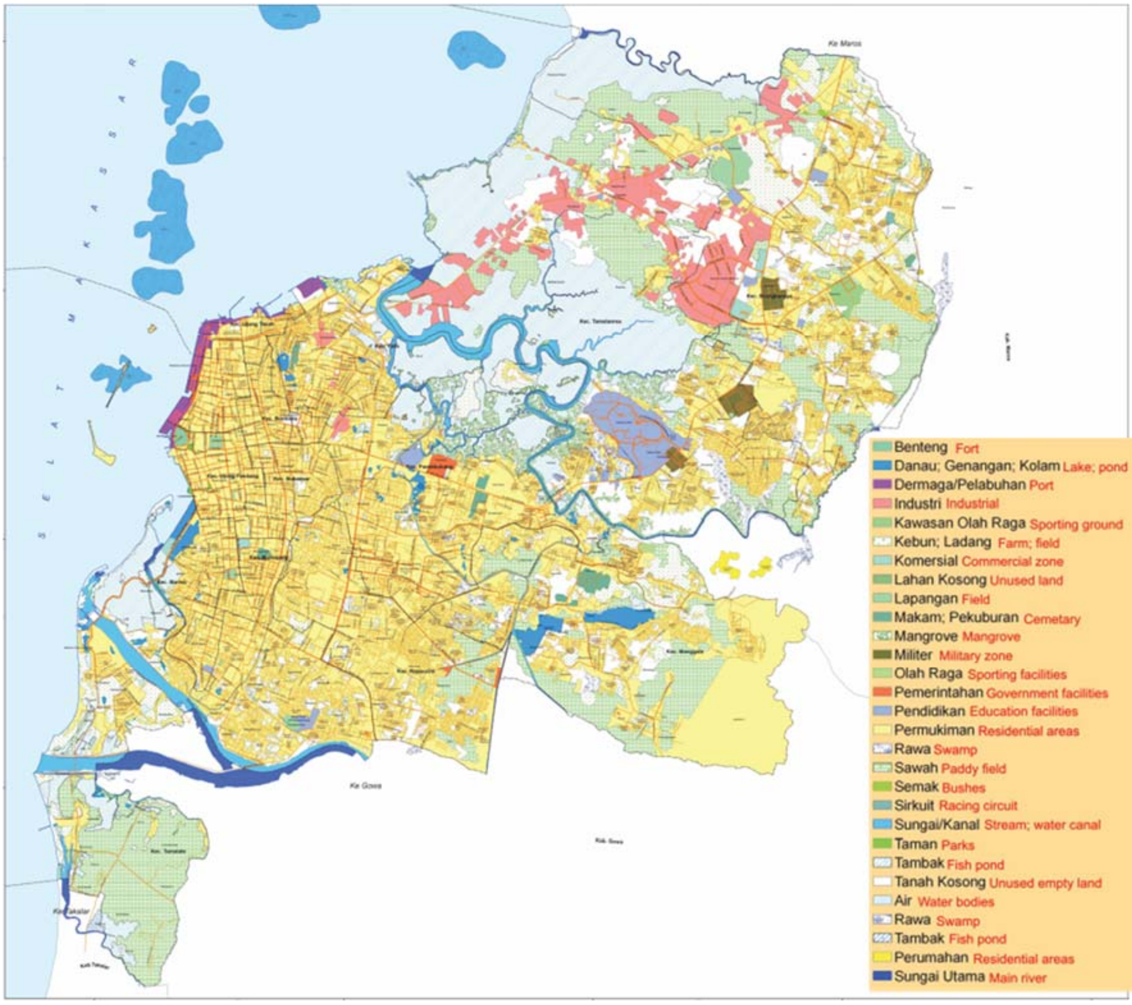

Figure 4.13. Land use map of Makassar, 2006
(Source: Makassar City Council)

Figure 4.13. shows the government acknowledges the existence of other land use types and status. These should be seriously considered by the government as part of its green plan.

This study needs to consider all available spaces regardless of their land status. The various land uses should lead to further classification of space, something which is necessary for Makassar city. This is due to the fact that classification of land uses as shown in Figure 4.13. appears too general for some types yet also too specific for others. In terms of functionality, there is also some overlap. Therefore it is important to introduce a better classification that represents all types of land use.

4.6. Greater Urban Region: Mamminasata

Development of Makassar and the surrounding areas of the city is inevitable due to the pressure of urban growth. The local authority has seen this and is responding by issuing a development plan which integrates the city with three adjoining regencies. Although this study cannot cover all three based on their administrative borders, it will consider the three regencies that have a direct connection with the Makassar major urban region (Figure 5.2).

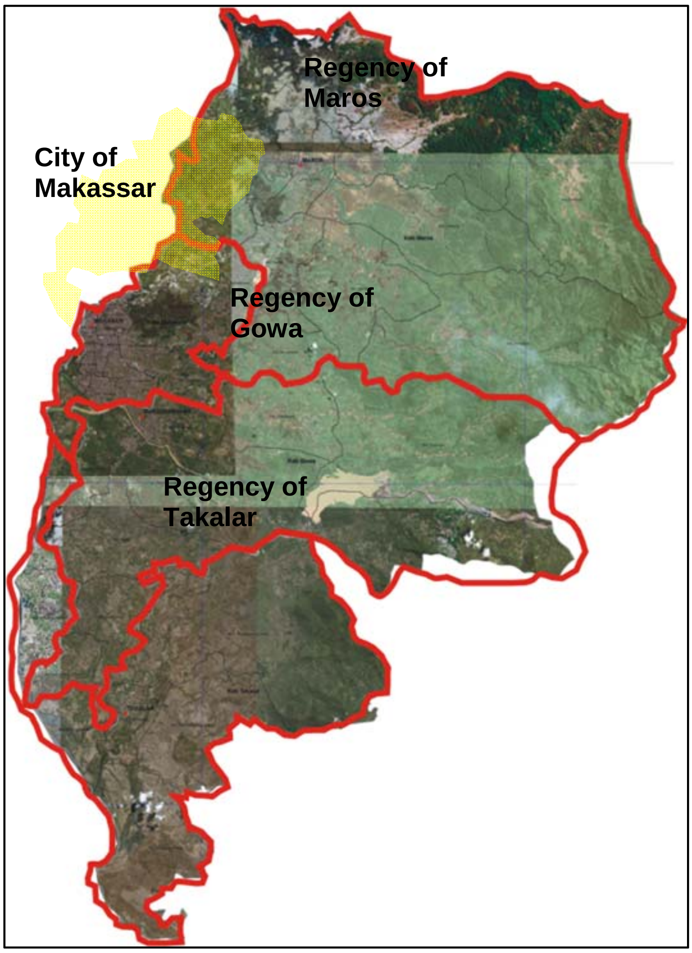

Figure 4.14. Makassar and its surrounding areas relevant for urban development

Figure 4.14 shows three surrounding regencies that might be affected by Makassar's growth and development. Through the presidential decree (2011) the government has declared for the integration of all four areas into the Greater Urban Region of Mamminasata (abbreviation of Makassar, Maros, Sungguminasa (Gowa) and Takalar).

This constitutes the area of integrated development for the spatial plan for the regions. Because of resources, this study will only make an inventory for Makassar, although areas outside the Makassar border are also taken into consideration, especially when the patches are continuous across a border or spaces outside Makassar are considered to be significantly related to spaces within it. Although general land uses and landscape characters will also be identified for this greater region, detailed assessment of spaces will not be undertaken, with focused on Makassar as the main city.

4.7. Summary

This chapter describes the history and existing condition of Makassar. Government initiatives are described, suggesting that the authority acknowledges the importance of ensuring there is sufficient green space in the built area of the city. However, it is unclear how and whether these targets can be met. The connection between Makassar and its wider region is established, along with the scope of this investigation.

The contribution of this research to meeting the green space targets through establishing an inventory of green spaces that reflects what is seen in the city of Makassar is described in the next chapter.

Chapter 5

Developing a Space Typology for a Network

5.1. Identification of all spaces regardless of land status

The starting point for this part of the investigation was the 2006 city council land-use map. For some land-use types this map appears too general while for others it looks too specific, and with some overlaps. Therefore for this study it was necessary to set up an inventory of all available spaces and their various land-uses in the city and construct the map in Figure 5.1. Apart from mapping the spaces, a data base was created that sets out the characteristics of and information about each space, something that was not available in the government map. This was done using aerial photographs, and includes all spaces already in the government map.

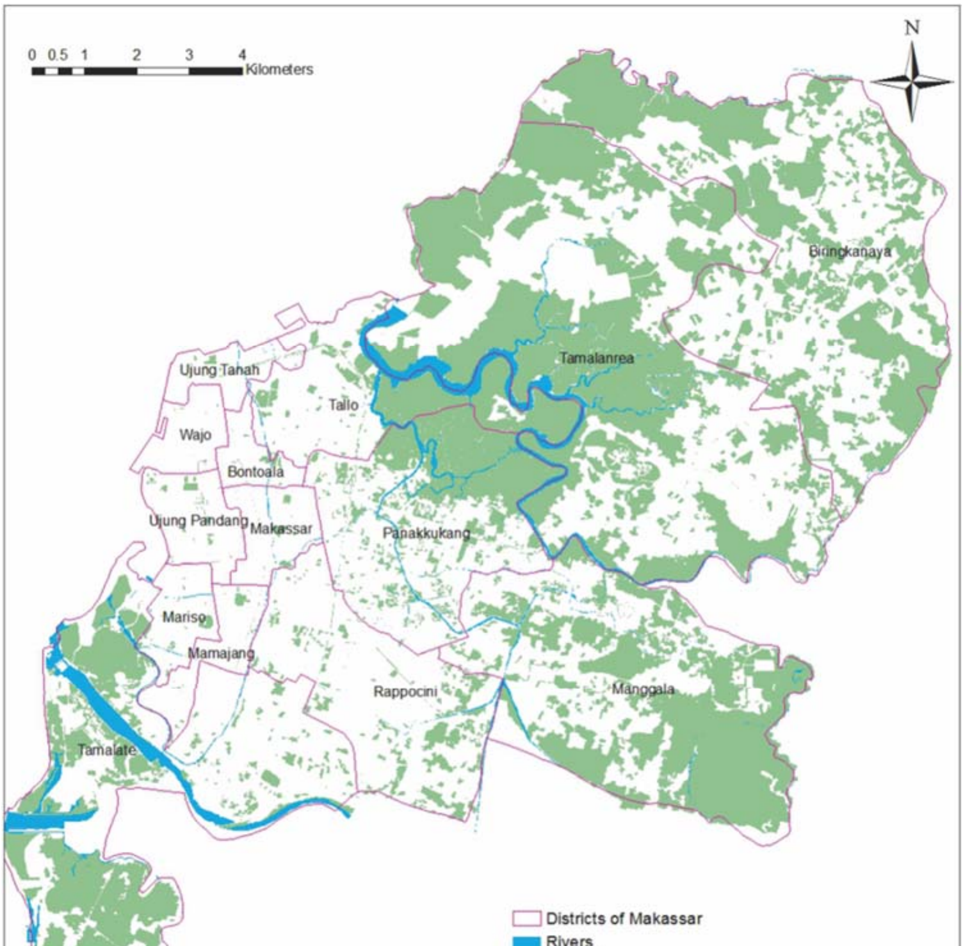

Figure 5.1. Open and green spaces in Makassar: results of study inventory mapping

Figure 5.1 shows Makassar seems to have significant amounts of open and green space (non-built area) with various land uses. The intention in this study is to classify these spaces based on a typology that considers land use and land status.

Table 5.1 presents all spaces identified by this study and the various types of land use they represent.

Table 5.1. All study identified spaces based on land uses

Land use	Area (ha)	Percentage (%)
Agriculture fields (including paddy field and mix crops)	2864.03	39.73
Building/property open/green space	7.35	0.10
Campus ground/park/open space	8.31	0.12
Cemetery	72.84	1.01
Commercial/business open space	0.49	0.01
Dam corridor	3.66	0.05
Dormitory yard	0.79	0.01
Fish ponds	1937.84	26.88
Golf course	10.02	0.14
Green corridors (of roads and river/stream)	35.93	0.50
Green space/public parks	96.46	1.34
Industrial open/green space	106.31	1.47
Institutional yard/open/green space	15.56	0.22
Marshland/water catchment area	415.17	5.76
Military ground/complex	2.49	0.03
Mosque/churchyard	0.43	0.01
Office yard/open space	3.67	0.05
Other empty/open field/space	752.11	10.43
Parking/service area	0.70	0.01
Residential space	113.74	1.58
Riparian zones; river/stream corridor	450.67	6.25
School yard	4.48	0.06
Shallow lake	6.75	0.09
Sports field/public field	9.01	0.13
Squatter settlement	0.70	0.01
Swamp	58.83	0.82
Urban forest (including campus ground designated for such function)	166.48	2.31
Others (unspecified)	63.73	0.88
Total	**7208.58**	**100.00**

The land uses in Table 5.1 are taken from the government description as well as the interpretation used in this study based on aerial photographs and site visits. The original government source has very many land uses, some of them overlapping, so simplification is required. One way of simplifying the classification is by introducing a typology which considers various aspects including the current land uses and types.

In order to analyse and assess the potential for a green network in Makassar, it is first necessary to evaluate the landscape structures in the Makassar urban region. For this, the landscape structure indices should ideally refer to landscape ecology principles, which include patches, edges, corridors and mosaics (Dramstad et al., 1996); (Richard T. T. Forman, 1995). However, this research is focussed on patches and corridors for two main reasons:

1) it is assumed that analysis of the edge is necessary for specific investigation of both plant and animal species;
2) the assumption is the existing ecology of Makassar is still engaged with the issue of green open space provision to help environmental quality, hence patches and corridors are more relevant and related to plants (Hidayansyah, 2007); (Gauk, 2009).

Knowledge about the importance of making use of green spaces in an urban area, as seen in many developed cities, has also inspired this research. The first need is to identify how the spaces in the study location are utilized and managed by the government. Therefore, the first important thing is creating an inventory of potential green spots and corridors. This will then be assessed to see how the things really are on the ground.

This stage is then followed by performing an assessment of the biodiversity of the spaces and the possible network. To do this requires regional and local scale GIS work along with ground observation as necessary, and supporting supplementary information in the form of government documents, plans, and previous studies and research.

5.2. Developing a typology of spaces

Before an appropriate ecological network can be implemented, knowledge based on spatial feasibility is an important factor. Spatial assessment is a process involving prior knowledge for identifying available and accessible spaces in an urban area and making an inventory of them. The feasibility of these spaces can then be determined after further analysis, including looking at ecological elements and biodiversity, and an examination of government plans and stakeholder preferences.

Spatial assessment is preferably performed thoroughly in order to identify all spaces and patches as well as corridors in the urban area. However this will be too intensive, complex and time consuming. Moreover previous studies have confirmed that most urban areas have specific habitat types (Tzoulas & James, 2010). This suggests that developing a list of common types of space in the urban area is an essential process in making an efficient and useful inventory without missing any potential spaces.

Officially the area of Makassar city is 175.77 km^2 (see Chapter 4) and is dominated by significant built area coverage. Open spaces consist of a large area of fish ponds, some scattered private green spots and limited public green spaces. In order to evaluate the existing potential of the city for the creation of a green network, it is necessary to make an inventory of all natural spaces that could be a part of the proposed network. Rivers that run across the city with branched tributary streams and canals, along with various classes of road networks could also function as good corridors, and these need to be included in the inventory.

Certainly not all existing spaces and corridors could be part of a green network; therefore a filtering process should also be performed as part of the inventory. This filtering analysis can be used to generate a typology that classifies space based on physical condition, ownership, potential, constraints, and other significant variables where appropriate

Because the size of the city makes it too time consuming to identify all of the spaces in it, the first stage is to simplify the process by examining one sample district of the main city in detail. Evaluation of the existing potential features for the creation of a green network is performed through detailed inventory in this representative sample district. This district must be selected according to the following criteria:

1) the area must be representative of others in terms of its size;
2) it should have various different types of land use which represent most of all kinds in the city;
3) and it should also have various types and sizes of corridors.

The district which fulfils these requirements is Panakkukang. It is not the biggest district in the City of Makassar but has almost all types of space according to the government classification (Minister of Home Affairs, 2007) which exist in Makassar. Apart from this, the district also houses different but representative types of facilities, such as schools, colleges and universities, government buildings, and a shopping mall.

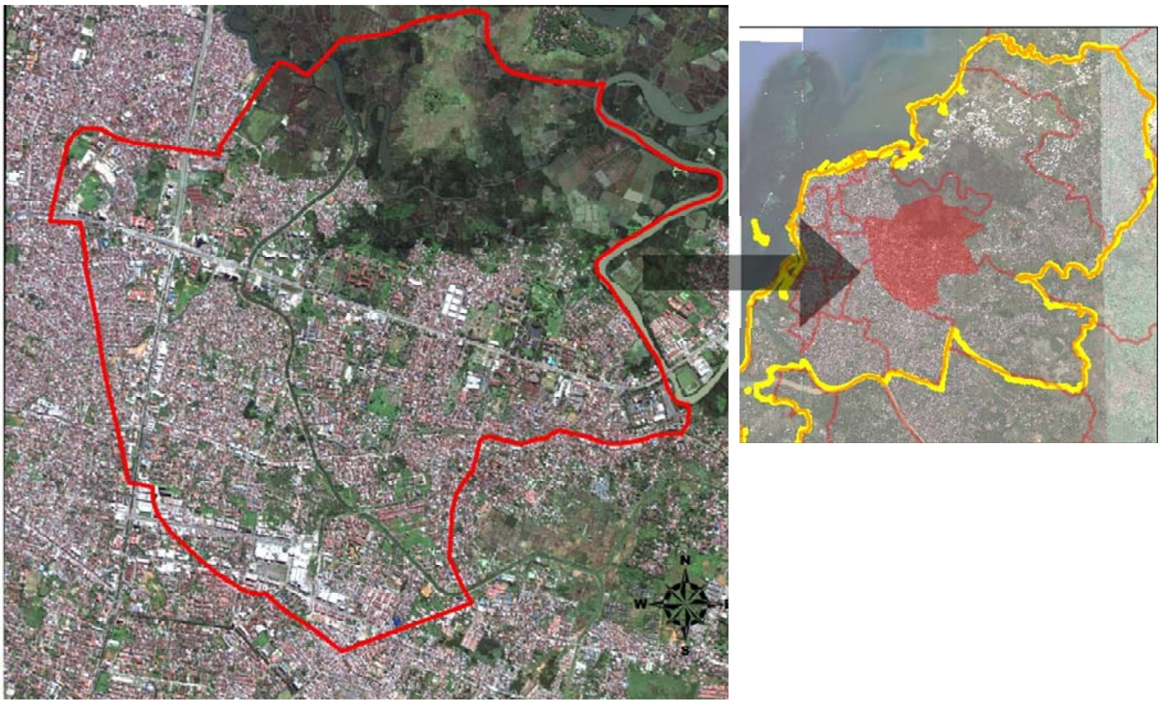

Figure 5.2. Indicative unscaled map, showing District of Panakkukang (red) and its position in City of Makassar (yellow)

The selected district is in the middle of the main city, therefore, it might appear that it only has urban spaces and is less representative of suburban areas. However,, as development of a typology does not mean distinguishing spaces based on vegetation density, spaces in the suburbs will be covered during fieldwork activities as long as they have similar land-use to one of the categories in the typology. It is also important to note that the massive development of Makassar reaches out to its edges, resulting in urbanized suburbs with spaces that are urban in character.

Using aerial photographs obtained from Google earth, a map of Makassar and the surrounding regions (including the target district) was retrieved at fine resolution, at the altitude of 500m where even small green spots can be clearly observed. This high resolution map is required in order to identify and meticulously record all green spots that have potential to be part of a green network. These spots include open spaces around residential areas, house yards, small spaces between built areas, institutional grounds, and agricultural areas. Then with the help of GIS, spaces are digitized in detail.

Following this, comes evaluation of the significance of certain typologies relating to the spaces and corridors. Afterwards, the typology developed from this district will be used to make a simplified inventory of the whole main city area as a second stage.

5.2.1. Urban green patches

In order to classify the spaces, knowledge of any existing classifications may help to narrow down the space focus and cross-check the spatial availability in the target area. In the study location context, such categorisation developed by previous studies is not available. What is available is the existing government classification Decree of Indonesian Minister of Home Affairs No. 1 year 2007 (Ministry of Home Affairs, 2007). This document shows that the district of Panakkukang contains nearly all named types of green space when compared to other districts, hence its selections as the sampling district for detail inventory in developing the typology. Table 5.2 presents spaces according to this document and shows whether the type exists in Makassar.

Table 5.2. Open space type according to government classification (Ministry of Home Affairs, 2007) and whether they are found in Makassar

Type of open space	**Existence in Makassar**
Urban parks	Small public parks*
Natural parks	NA
Recreational/outdoor amusement parks	Small area around public parks
Neighbourhood gardens of residential areas	Open space in some residential complexes*
Neighbourhood gardens of commercial and office buildings	Open space within some business complexes*
Forest parks	NA
Urban forests	Institutional space such as campus grounds and governor's office have been labelled urban forest*
Protected forests	NA
Natural landscape characteristics (such as mountains, hills, hillsides and slopes)	NA
Natural reserves	NA
Botanical gardens	NA
Zoo	NA
Public cemeteries	Available*
Sports fields	Available*
Ceremonial fields	Sports fields commonly used as ceremonial fields*
Open parking spaces	Roadside parking is more common than open parking space*
Urban farms	On edges of urban development*
Power lines	All over city*
Riparian and buffer zones (of rivers, shoreline, buildings, preservation sites and wetlands)	River corridors and wetlands*
Corridors (roads, railway, pipelines, footpaths)	Road corridors*
Green zones and lines	Undisturbed green zones and lines barely available
Airport buffer zones	Open area around airport, whether designated as buffer is unclear
Roof gardens	Initiatives have been made individually

Source: Ministry of Home Affairs (2007) compared to observable condition in Makassar
* Exist in the district of Panakkukang

As seen in Table 5.2, not all types are found in Makassar city. Moreover, the classification above does not include watery areas such as lakes and fishponds, whose area and edges could be utilized. In addition, some types when looked at from an ecological perspective in regard to land use and biological content and activity are somewhat overlapping. For example natural parks, urban forest and forest parks would presumably have similar ecological value. The difference lies in the level of accessibility, which is something manageable. Therefore, this study needed to re-classify the spaces and simplify the types, and at the same time differentiate between them based on principal considerations, which will be combined with land utilization and management aspects.

The considerations behind space identification have nothing to do with space size, since knowledge of any possible spaces, regardless of size, ownership or current use will help to assess the total potential. Therefore the inventory of green patches should include all spaces that, according to Harrison et al (1995), could be defined as natural green space. Such spaces are sites awaiting development, ponds, rivers, and any form of reservoir, and incidental pocket sized areas associated with residential and commercial facilities.

5.2.2. Assumptions made prior to typology development

The inventory work identified spaces based only on their appearance in the detailed aerial photographs. No information regarding other qualities could be retrieved, although it is important to have an understanding about these qualities for further stages in the spatial and functional investigation. This particularly applies to patches as they are more varied and complicated, whereas corridors tend to be simpler and have very limited possibilities (if any) for variety of use and function.

Therefore, spaces seen in the aerial photograph are then analysed with regard to other relevant aspects in order to assess their level of significance for the possible ecological or green network. Table 5.3 below shows some of these aspects with an explanation, based either on prior knowledge about the local circumstances or government land use maps and information. The table does not present a description of all items which could be related to the features being assessed in the detailed inventory, but only those which might need further explanation.

Table 5.3. Some aspects of assessment for evaluating the spaces identified in the sample district

Aspect of Assessment	Types/Level	Description
Existing Function (despite the current land use, judged on state of coverage)	Open Empty Field	Spaces without built structures which are left without clear function, mostly unplanted and predominantly grassed.
	Open field	Spaces without built structures which are fully or partially vegetated and mostly have existing function
	Green spot	Space that is already dense with vegetation, mainly trees
State of Ownership (based on land use and type and local knowledge)	Private	Space that is house yard, small business site or residential complex. All are assumed to be privately owned; hence they pose limitations for physical access and possibility for imposition of green network
	Institutional ground	Space not belonging to an individual but owned by a certain private organization or government agency/department
	Public	State land or any spaces under government management
Level of Accessibility (Based on proximity to road infrastructure, and the matrix around the space)	Low	Spaces which are privately owned and located within a housing complex with small and narrow roads. Visual and physical accesses are either limited or even prohibited
	Medium	Spaces that could be private properties but that are located on secondary roads or not far from main roads, hence can easily be spotted and visually accessed, yet physical access might still be limited or not possible
	High	Spaces that could be private or state properties, located on main roads with available public transport. Hence, these spaces can be easily accessed visually and physically (physical access might also be determined by state of ownership)
Biodiversity Level (assumed based on their vegetation cover as it appears in the aerial photograph)	Low	Spaces with dense or sparse single type of vegetation, or sparse multi type vegetation. Based on location, these spaces are subject to various disturbances
	Medium	Spaces with various dense types of vegetation, but where the space is still subject to disturbances by human activity or adjacent land use
	High	Large spaces which are in proximity to or part of natural landscape elements such as woods, rivers, lakes, ponds, traditional agriculture sites, etc. With relatively low human interference and with richness in vegetation type and structures, these sites are assumed to have high levels of biodiversity
Constraints/Hazard (assumption based on their current land use and status)	Land conversion	There is possibility that the area is a subject for land use change (insertion of infrastructure or other built structures), especially for private property. The conversion could claim part or the whole area which means this open space could disappear.
Possible proposed action/function (Assumption projected based on the current use and status, location, existing land coverage and local knowledge)	Preserved spot	Areas which are already vegetated/planted with vegetation at a certain stage and which are considered to have value and potential as green spots; hence they are suggested to be maintained/preserved or enriched
	Park with ponds	Areas which have threat of flooding from storm water or stream overflow; the size is significant but these have potential to be designed as accessible parks with pond as water catchment and at the same time carry value as habitat for water species.

Table 5.3. Continued

Possible proposed action/function	Neighbourhood garden	An open area of significant size that because of its location and accessibility within the neighbourhood could be developed into a public garden; however land ownership might still be an issue
	Green yard	Private house yard; could be made better by making it greener with gardening
	Parks	Large non-private space which could be developed into public parks
	Planting ground	Areas which because of either unfavourable accessibility, existing function or less manageable condition are better optimized by planting fully or partially with more plants/trees in order to make them more aesthetic or greener
	Green space	Spaces which are very significant and have potential, in terms of size and location, to be developed into proper functional green space; land ownership might also be an issue
	Sports field	Spaces which based on location and current use have potential to be developed as neighbourhood sports ground
	Urban farm/vegetable farm	Spaces, based on current use, location or existing conditions, that have potential to become productive land for limited urban agriculture

5.2.3. Patches

The detailed inventory with the assumptions shown in Table 5.3 of the selected sample district (Panakkukang) therefore looks at all possible significant spaces according to present land use and spatial observation. This process led to the production of a typology of spaces as described below.

5.2.3.1. Inter-house space

This is a space between houses; either part of the house(s) or belonging to the housing developer. This includes spaces that are completely surrounded by houses and have no access from public roads.

Figure 5.3. Example of inter-house space

5.2.3.2. Commercial space

Similar to inter-house space but specifically between commercial or industrial buildings or facilities, regardless of ownership.

Figure 5.4. Example of commercial space

5.2.3.3. Un-built space

Spaces located adjacent to houses or commercial buildings, which are therefore assumed to be associated with them, including spaces within a residential complex, that have good access to roads. They are either private or public spaces waiting for redevelopment or have been deliberately left open, are not surrounded by buildings and have openness on at least two sides.

Figure 5.5. Example of un-built space

5.2.3.4. Empty field

Spaces which are empty and not clear regarding their association with a particular building or property, having open access from at least one direction. Most are quite large in size. The adjective 'empty' refers to the lack of built structures within it, but it could be a densely vegetated area.

Figure 5.6. Example of empty field

5.2.3.5. Institutional space

Part of the property of an institutional private organization or government agency or department, or a hotel or mall, including schools, campus, military complexes and office grounds.

Figure 5.7. Example of institutional space

5.2.3.6. Public field

Spaces that regardless of ownership have been used by the public living nearby for various activities. These spaces are frequently used as a playground, sports ground and space for community gathering and meeting, hence in general they are lacking in vegetation. Sometimes they are used for parking or as a shortcut thoroughfare.

Figure 5.8. Example of public field

5.2.3.7. Public open/green space

State-owned spaces allocated for the public for various functions, including recreation. These include public green space within a residential complex.

Figure 5.9. Example of public open/green space

5.2.3.8. Wetland

Watery area close to a river or stream. Two main types are marshland, located around residential areas, and swamp, mostly located by riverbanks and dominated by woody plants.

Marshland

Swamp

Figure 5.10. Examples of wetland

5.2.3.9. Fishpond

Artificial reservoir (pond) intended for fish breeding

Figure 5.11. Example of fishpond

5.2.3.10. Urban farm

Areas which are used for farming by people living nearby, mostly with seasonal plants, including paddy fields.

Figure 5.12. Example of urban farm

The distribution of these spaces for the District of Panakkukang is shown in Figure 5.14 below.

The typology developed above represents the main types of green patches existing in the city of Makassar. The spaces listed in the classification are based on the spatial inventory and are quite varied in terms of factors such as state of ownership, accessibility and vegetation structure. Therefore, in regard to their likelihood of being part of the green and ecological network, it is important to appraise their constraints and potential as well as their existing plant biodiversity and current function and use.

Consequently, using this typology, the full inventory of the whole city area will focus only on spaces which belong to one of the types in the list based on their characteristics. As in Table 5.3, this means considering aspects such as current land use and function, existing condition, and possible future development.

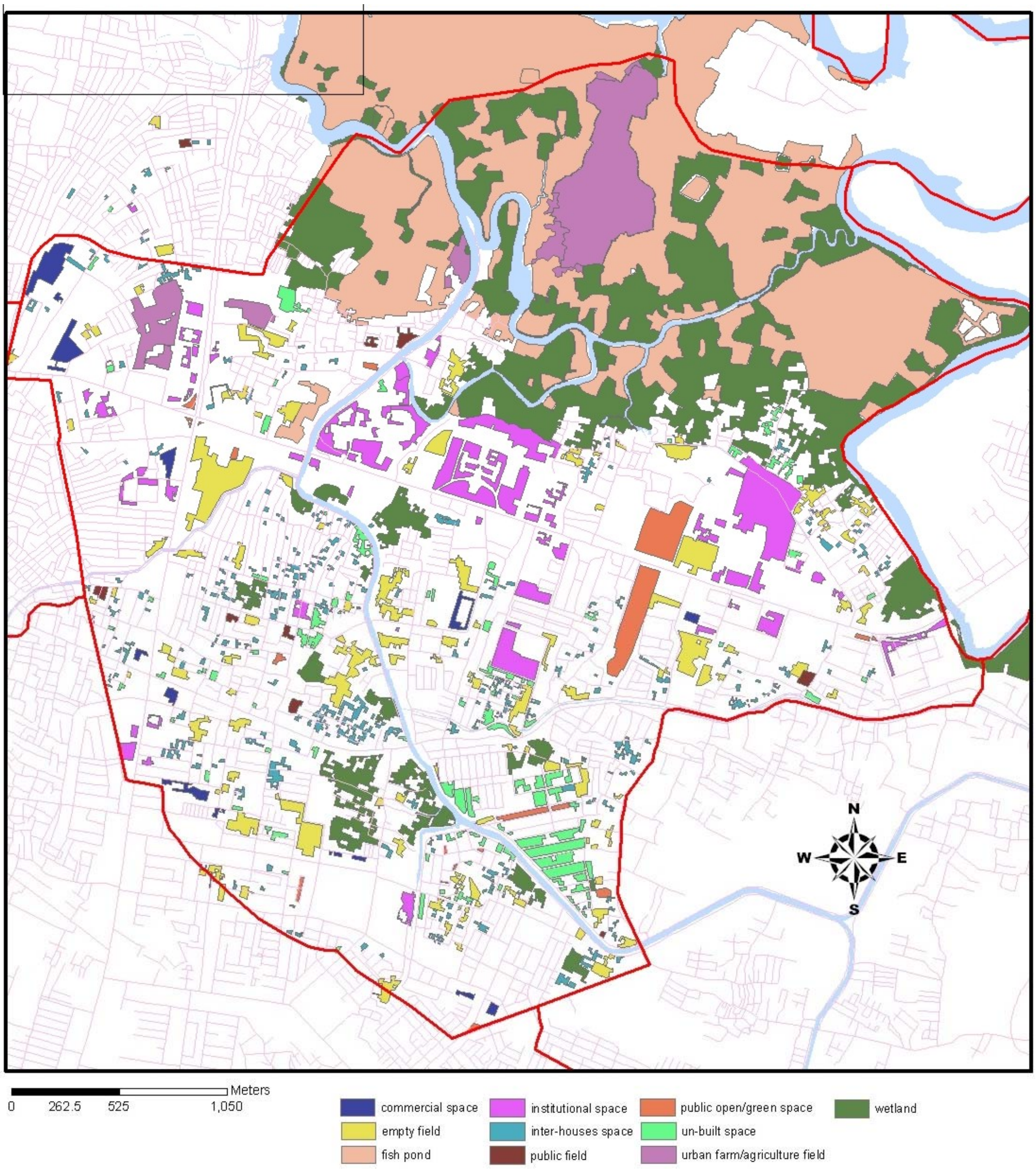

Figure 5.13. Distribution of spaces according to the typology in the sample district

5.2.4. Corridors

Similar to the green spaces (patches), green corridors in the sampled district are also identified in detail in order to get information about the type available and their potential to be part of a green network. There are two main types of corridor in the city: rivers and streams, and roads. In addition, there are green rows formed by connecting house yards or other property.

5.2.4.1. Water corridors

All water corridors are important supports for a green network as they are more likely to be natural and rich in biodiversity.

The two main rivers that go through the city of Makassar are the Tallo and Jeneberang, with the Pampang being a minor river. These rivers are potential corridors and their formation could be combined with authority efforts to improve the condition of the watershed along the river. The main aim of the latter is to control the overflow during the rainy season, but it could also mean improvement in the ecology.

Apart from natural river and stream corridors, there are also canals built for flood control. Although these canals mostly run across the main built areas with less space for making them into green corridors, it is still important to include them in an inventory as their ecology might be improved.

5.2.4.2. Roads

Regarding the function of roads, there are two general main types and four elaborated types of urban roads according to the Indonesian National Standard (2003) No. 03-6967-2003 for the general requirements of road networks and housing roads. This standard is also in line with the 'Guidelines for Classification of Urban Road Function' published by The Ministry of Public Works.

These roads are:

1. Primary roads that are continuous and connect main cities to other main cities or to smaller cities and regencies within a province

2. Secondary roads that connect areas within a city or urban area. There are four sub-types of these roads depending on the distance and travel characteristics and average speed allowed:
    a. Arterial roads, and public main roads that serve long distance travel, with high average speed and limited number of connecting driveways;
    b. Collector roads that take traffic from local roads, and distribute it to arterial roads, with average medium speed, also with limited entrances. Traffic using a collector road is usually going to or coming from somewhere nearby.
    c. Local roads, having the lowest speed limit, for short distances, low speed travel and unlimited entrance connections. Commonly such a road carries low volumes of traffic
    d. Housing environment road is a public road within a residential or other specific complex.

The different functions that each road type serves means their physical appearances, such as width and road section, are also different. This therefore determines the possibility of utilizing space on the roadside as a green corridor. The road corridor typology will refer to the official classification of the roads, but in order to simplify the inventory, the roads will be divided into three classes:

1. Primary road as in the official classification
2. Secondary road (arterials and collector roads)
3. Tertiary road (local and housing environment roads).

Road corridors could be spaces which run along roadsides or in the road median. The appearance might be a row of vegetation or just an empty earth-surfaced corridor. This produces the following considerations leading to the formation of the corridor typology.

5.2.4.3. In-property corridors

In-property corridor is a term to describe the green corridors formed by a row of trees or various vegetation types that grow in a certain type of property. Although these sorts of corridor are unlikely to be continuous, they could still serve a function on a site where water or road corridors do not exist or cannot be established.

Based on the corridor classification above, an inventory of green corridors was made by looking at the existing vegetation condition in those corridors. A typology was also developed as presented below

1. Primary road corridor

   Green corridors along a main road connecting main cities or primary locations. The plants either grow along the roadside or in the median strip, or both.

   

   Figure 5.14. Example of primary road

2. Secondary road corridor

   Plants grow along arterial and collector roadsides but there are also rows of vegetation grown in house yards or other properties that often run parallel to the road corridor.

   

   Figure 5.15. Example of secondary road

3. Tertiary road corridor

   Most are residential roads; therefore green corridors are formed by rows of trees in private house yards.

Figure 5.16. Example of tertiary road

4. River corridor

   Green corridor alongside a river

Figure 5.17. Example of river corridor

5. Stream and canal corridor

   Corridors alongside natural or man-made streams and canals

Figure 5.18. Example of stream/canal corridor

6. In-property corridor

   Connection of vegetation in house yards and other properties. These could be rows of trees in backyards or along a private property road corridor, and might not be in proximity to public roads.

Figure 5.19. Example of in-property corridor

The distribution of green corridors as described in the typology for the District of Panakkukang is illustrated in Figure 5.21 below

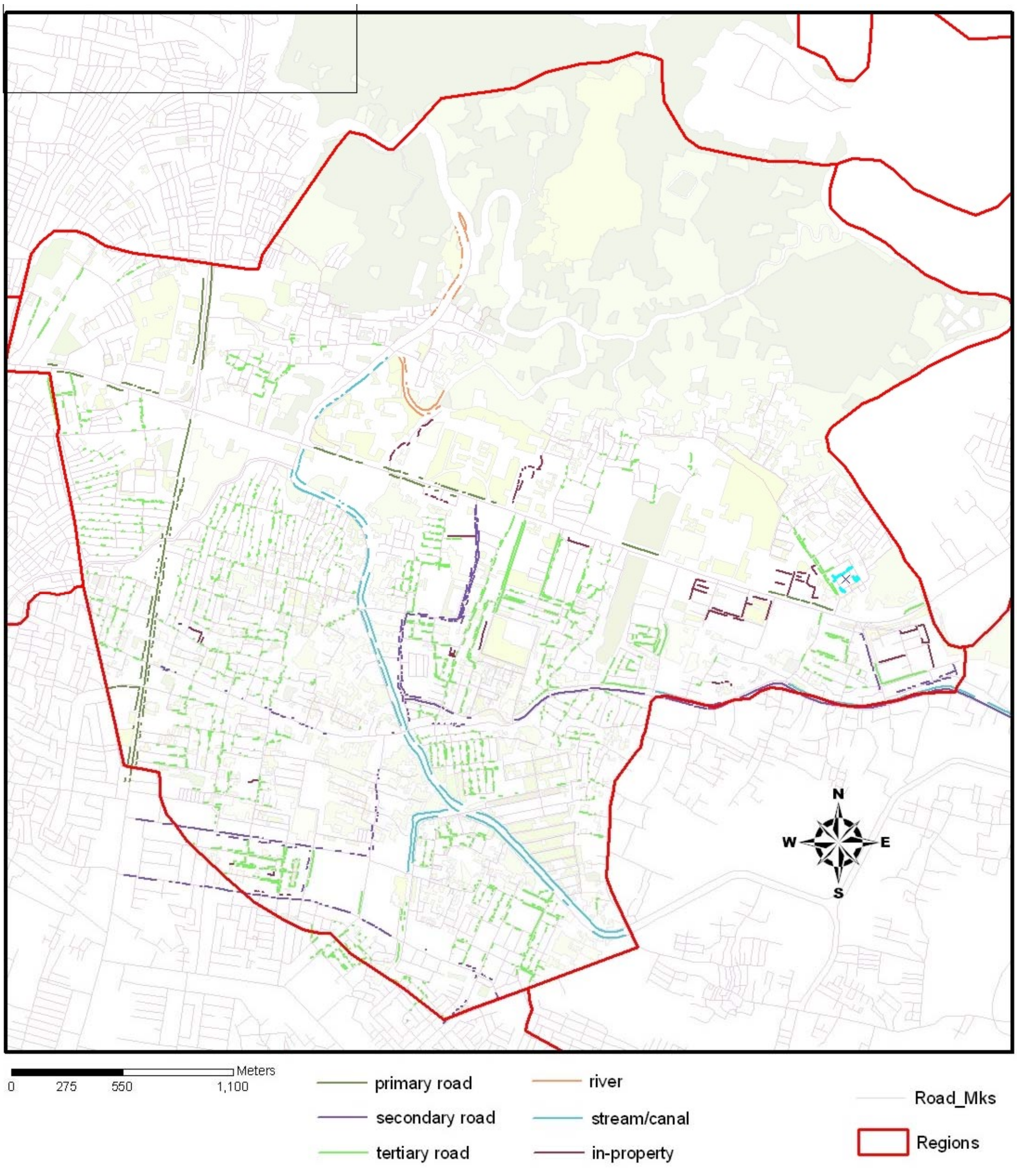

Figure 5.20. Distribution of green corridors according to the typology

The typology for both patches and corridors as developed above should represent the main types of patches and corridors in Makassar. Regarding their likelihood of being part of a green or ecological network, it is important to appraise their constraints and potential in terms of state of ownership, accessibility, and vegetation structure, as well as their existing plant biodiversity and current function and use.

5.3. Applying the typology to the whole city and making priorities for fieldwork

5.3.1. Typology for the whole city

Although the typology of spaces was developed from the detailed assessment of one sample district it is considered sufficient to represent the spaces of the whole city, given it was developed from the existing government's land use types, almost all of which exist in the sampled district (Table 5.2). The types missing are either not found anywhere in the city or have been subsumed into one of the developed typologies, thus making these representative of the whole city.

With this typology, identification of spaces for the whole city can become more focused with the simplified classification suggested. This typology brings together land uses and types by looking particularly at similarities in their physical appearance and ownership aspects.

A thoroughly detailed identification of spaces was performed in the sample district (Panakkukang) in order to be able to invent a proper typology. Even small lots of private inter-house space were identified as long as they were clearly observable during the mapping process using aerial photographs from Google earth's 500 m-altitude image.

Although a better resolution aerial photograph was used for identification of spaces in the whole city, this study set the minimum area for inclusion as $50m^2$, even for small inter-house space. Therefore some spaces which were identified during the typology development process in the sample district were not included in the identified spaces of the city. However, as the city space mapping also included some spaces and corridors derived from the government's official inventory spaces, some new small spaces appeared. This is due to the fact that some patches from the government inventory rather than being individual patches are groups of several variously sized patches. Exploding these kinds of patch consequently resulted in the appearance of some small spaces.

The assessment regarding the quality of the spaces (Chapter 8) filtered them based on factors including size. The typology of all spaces of both patches and corridors is shown in Figure 5.22.

5.3.2. Priority analysis for fieldwork assessment

Having classified spaces into the typology this study needed to assess the quality of spaces for their possible inclusion into a green network for the city. Given the immense number of spaces in each typology, it is essential to justify the priorities for selecting those spaces which will be further assessed through site visits and field work activity.

One method would be for assessment of biodiversity to be performed using a suitable method for each of the identified space types. The number of sampling points, location, and other technical aspects would be considered in line with which biodiversity assessment method is to be used. However, preference could be given to types which have significance in terms of their potential for inclusion into a green or ecological network for the city. Therefore some consideration needs to be given to determining which identified spaces possess such significance. Table 5.4 presents aspects of such consideration and how they relate to the space typologies.

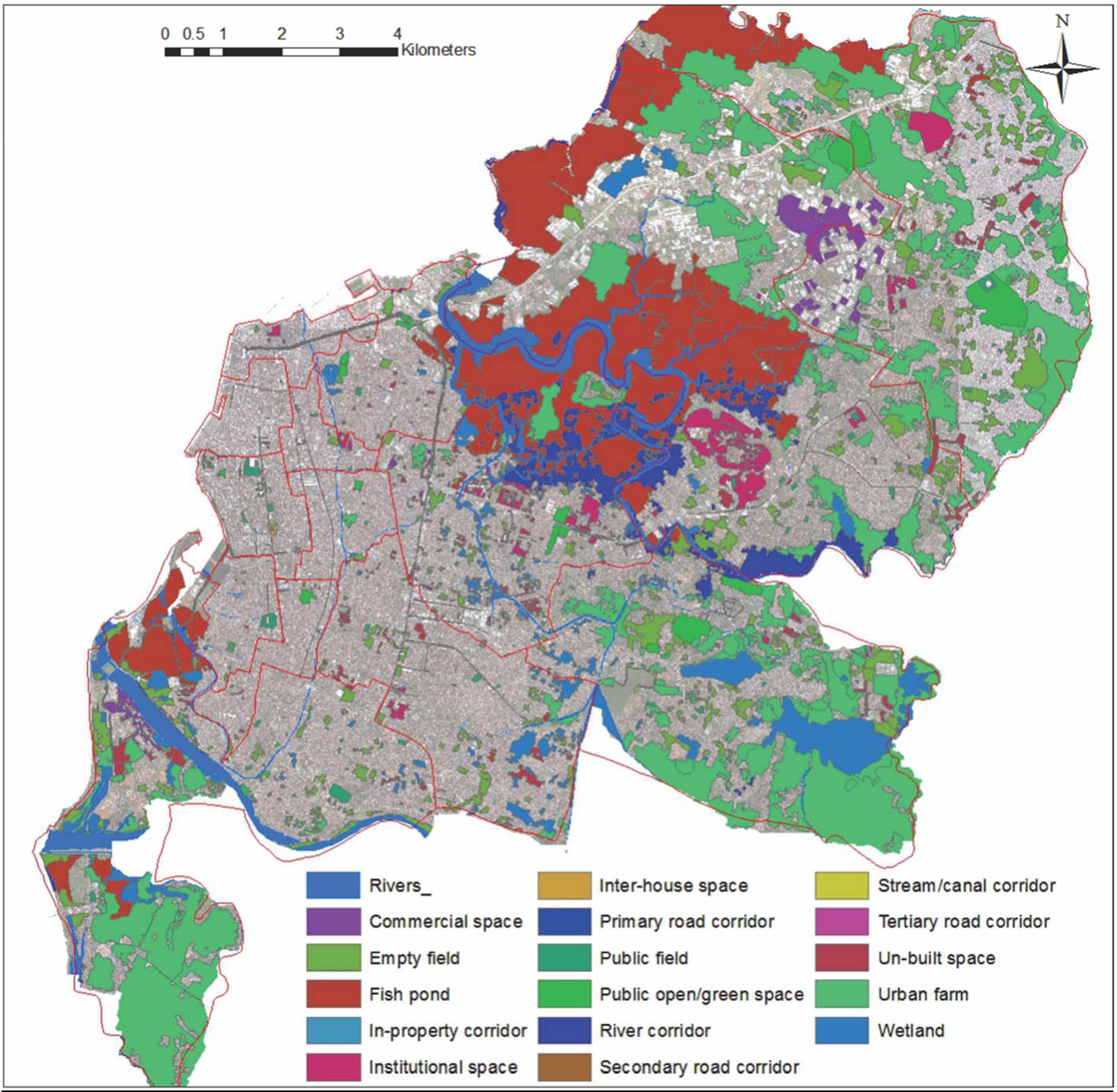

Figure 5.21. Typology of spaces in the city of Makassar

Table 5.4. Comparison between identified spaces and aspects for making priorities for fieldwork

Typology / Comparable aspects	Inter-houses Space (IH)	Commercial Space (CS)	Un-built Space (UB)	Empty Field (EF)	Institutional Space (IS)	Public Field (PF)	Public open/green Space (OG)	Wetland (WL)	Fish Pond (FP)	Urban Farm (UF)
State of ownership	Mostly private space	Mostly private with some owned by certain institutions	Mostly private space	Some are private spaces waiting for development, some are state land in a location not suitable for building	Owned by the institution, ranging from private institution to government agency	Most need further confirmation as this type of space could be private or state land	State land or spaces within a residential complex that belongs to the developer	Mostly state land but some belongs to private developers who are planning to build on the area (with major earthworks)	Need to confirm whether fish pond is owned by individual farmer, big corporation or is state property utilized by farmer with consent	Similar to fishpond
Accessibility	Visual and physical access is either limited or prohibited	Most are visually accessible, but might not be physically accessible	Depends on location and state of ownership	State-owned empty fields are normally accessible	Because these institutions provide services to people, the space within the complex is considered public space, therefore accessibility is quite open. They are commonly also in strategic locations	In terms of entry access they are mostly accessible. Some public fields are within neighbour-hoods with narrow roads, hence hard to notice visually	Spaces mostly, located on main roads with public transport. Hence, these spaces can be easily accessed visually and physically	They are located alongside river/stream, spaces that cross the city, so are easily accessible, but swamps along main river are difficult to access physically	Most are located in the fringe with limited road access	Limited visual and physical access
General size	Small	Small to medium	Small to medium	Small to large	Small to large	Small	Small to medium	Medium to large	Large	Medium to large
Vegetation structure	As these spaces are mostly house yards vegetation cover is varied. Some are dominated by trees and appear as green spots. Some are beautiful gardens, and some are left open with only grass/ground cover. Vegetation is mostly exotic	These spaces are commonly waiting for development therefore they are dominated by various ground cover with some shrubs	Most un-built spaces are to be re-developed, therefore they are left open without trees and dominated by ground cover and some shrubs	Frequently accessed, they are mostly left open with grass cover. However some have been left empty for a long time and have more varied vegetation, even trees	Range from open field with ground cover to dense green area with trees and multi levels of vegetation. Some are also well landscaped	Barely vegetated as these spaces are used for dynamic activities	Planted, landscaped and maintained in form of urban park, neighbour-hood garden, green space etc.	Mangrove and other woody plants in swamps and herbaceous water adaptive species in marshland	Mostly without trees, limited plant species grown in the dykes	Mainly agricultural, mostly seasonal plants. Paddy field is exception and more homogeneous than other crops

Table 5.4. Continued

Typology / Comparable aspects	Inter-houses Space (IH)	Commercial Space (CS)	Un-built Space (UB)	Empty Field (EF)	Institutional Space (IS)	Public Field (PF)	Public open/green Space (OG)	Wetland (WL)	Fish Pond (FP)	Urban Farm (UF)
Possible variety of function	Green yard, house garden	Landscaped garden, green spot	If small it can be green yard., neighbourhood garden, planting ground if quite large	Sporting ground, green space, planting ground,	Green space, urban park, urban habitat	Sporting ground, neighbourhood garden	Recreational sites, urban park, urban preservation spot	Water catchment area, planting ground, green space, protected ecological spot	Ecological urban fish pond	Urban farm with ecological value. Paddy field with enriched dykes
Possible users/ beneficiaries	Availability limited to owner of the property	For management and limited visitors	If the space is given up for public use then it can be useful for people in the neighbourhood	People in the neighbourhood	Immediately beneficial for people related with the institution, but in general the space is open to the public	All people in the community around the place	Open for all people	Anyone can benefit from improved wetland	Anyone can benefit from improved fishpond	If farming system ecologically improved, the whole city can benefit
Assumption for Biodiversity	Low	Low	Low	Low, could be medium for spaces that are left for long time	Low to medium depending on the size and level of disturbance	Low	Low to medium	Medium to high	Medium to high	Medium to high
Possibility of becoming ecological site and urban habitat	Unlikely	Unlikely	Unlikely	Less likely	Likely but depends on the type of ground and level of disturbance	Unlikely	Less likely because of high human use, but likely for more natural park with limited human access	Very likely	Likely	Likely to very likely
Possible constraints	This kind of space is commonly private so its future is unknown because there is no scheme to regulate the use of private space by the local authority	Commonly owned by private sector, and with no local authority access or method for joint management	These spaces are subject to redevelopment therefore land conversion is likely to occur.	State of ownership needs to be confirmed before possibly including these spaces into the network concept	The location is commonly within building complex owned by corporate institution providing public service, therefore potential for disturbance is very high	With high level of people activities, possibility of disturbance is very high	Spaces like these which are accessible and provide direct benefit for people are very limited. Almost no spaces like these have concern for ecology and species habitat	Main threat is over flow from the river/stream in the rainy season	Management and culture technique used is probably not environmentally friendly. No concern at present for ecological aspects	Intensive farming might not be favourable for some ecological species. Intensity of disturbances in agricultural landscape is great as the farmer is the most influential decision maker

Table 5.4. Continued

Typology / Comparable aspects	Inter-houses Space (IH)	Commercial Space (CS)	Un-built Space (UB)	Empty Field (EF)	Institutional Space (IS)	Public Field (PF)	Public open/green Space (OG)	Wetland (WL)	Fish Pond (FP)	Urban Farm (UF)
Possible potential	The number of such spaces in the study location is very high, so great potential if they could be linked The government needs to learn from Japan (Carmona et al., 2004), where the government regulates a scheme for managing privately owned green space	Similar to inter house space, and under mutual agreement, this kind of space could be significant for the city	Because space like this is not enclosed/ surrounded by built structures, it has better access from more directions. Therefore, when possible and manageable, such spaces have potential to be developed into public accessible green space	Most spaces like this are in strategic locations, have significant size and good access, therefore these spaces could make good accessible public parks	Local authority could probably cooperate with institutions concerned in making the space available as part of the green network, especially when the institution is a government agency or private sector partner with government. Campus grounds usually have more potential, because of size and the fact the academic community would be more receptive towards concepts such as green networks. (Hasanuddin University of Makassar campus ground has officially been named as a green space area of Makassar City)	Space like this, usually in a strategic location, is also usually large enough for public activities. It has potential to become neighbour-hood park/garden	Although the amount is limited, such space can be optimized to be part of a network	The wetland nature of these spaces makes them less likely to be built on.	Fish ponds cover huge areas of the city and the suburbs. They could accommodate viable habitat and ecological spots	Although land conversion is still a threat, urban farm land tends to remain green and rich in terms of vegetation structure

Using the typology and comparison of each type of green space, it is important to set up a matrix of priorities. Although sometimes the application on the ground regarding the final site selection does not often reflect the priorities identified through analysis, 'prioritization' has become a part of scientific application (Corlett, Richard T., 2009).

This matrix will help to determine levels of priority for deciding which types of patch and corridor are more feasible to be part of a green network for Makassar City. By having patches and corridors which are assumed to have a high priority, the next stage of the study will be more focused on those particular patch and corridor types, including undertaking field observation and biodiversity assessment of them. The following matrix scores the ease by which an aspect will lead to the incorporation of the type into a green network, using low L=1, medium M=2 and high H=3. The overall score is given in the final column.

Table 5.5. Matrix of priority

Typology Type	**Level of possibility** to be part of green network in terms of some comparable aspects									Overall Level of Priority		
	Ownership (conversion possibility)	Accessibility	Size	Vegetation (structure, richness, habitat potential)	Possible variety of function	Possible users/ beneficiaries	Assumption of Bio-diversity	Possibility to become ecological site and urban habitat	Overall score	**High**	**Medium**	**Low**
Patches												
Inter-house space (IH)	L	L	L	M	L	L	L	L	9			✓
Commercial space (CS)	L	L	M	L	L	L	L	L	9			✓
Un-built space (UB)	L	M	M	L	M	M	L	L	12			✓
Empty Field (EF)	M	H	M	M	M	M	M	M	17		✓	
Institutional space (IS)	M	H	H	M	M	M	M	M	18	✓		
Public field (PF)	M	H	M	L	M	M	L	L	14		✓	
Public open/green space (OG)	H	H	M	M	H	H	M	H	21	✓		
Wetland (WL)	H	M	H	H	M	M	H	H	21	✓		
Fish pond (FP)	M	L	H	M	L	L	H	H	16		✓	
Urban farm (UF)	M	M	H	H	H	L	H	H	20	✓		
Corridors												
Primary Road	H	H	H	M	L	H	M	M	19	✓		
Secondary road	M	M	L	L	L	M	L	L	11			✓
Tertiary road	H	L	L	H	L	L	L	L	12			✓
River	H	M	H	H	H	L	M	H	20	✓		
Stream/ canal	H	H	L	L	L	M	L	L	13		✓	
In-property	L	L	L	H	M	L	L	L	11			✓

From Table 5.5, there are 6 typologies which will be given priority in the fieldwork because they score high in the priority analysis. Institutional space is certainly important as according to the government inventory, some institutions have given up their space to be part of an official urban forest in the city. Wetlands and urban farms comprise a significant area of the city, and should therefore also be a point of focus. Corridors considered important in the fieldwork observation are primary roads and river corridors, and both are also important features in green networks already implemented in other places.

Having worked out the priority level, the field data collection stage can be more focussed on the typology of patches with high priority level. Although it would be ideal to assess all spaces identified in the typology equally, given the limited time and resources available, sampling and field data collection should be more intense for sites of high and medium priority. However, the other typology types are also visited and assessed.

The target for the fieldwork is not only assessing the extent to which these spaces are really available and have the potential to be part of a network, but also how much they could serve as an ecological spot (somewhere where species can have a permanent home). A sufficient number of such spots could then form a network of spaces with ecological quality. Therefore an assessment of current biodiversity was chosen for the purpose and the method used is appropriate for the urban context, as described in the next chapter.

5.4. Summary

The process of typology development as an important stage in this research has been described in this chapter, as well as the background behind assessing spaces for the typology development and reflection on priority determination for fieldwork activities. The typology was developed through a detailed mapping inventory in one sample district in the city. The selection of sample district as a measure for simplifying the detailed mapping work was based on it being representation of the whole city, as no on-the-ground preliminary observations were performed before fieldwork. The developed typology was then used in identifying green spaces for the whole city. The typology also distinguished between green spaces (patches) and green corridors, mapping both.

The chapter ends by considering factors with which to analyse fieldwork priorities. This is important to ensure that the fieldwork is both practicable and efficient given the limited time and resources.

Chapter 6

Biodiversity Assessment and Biodiversity Scoring

This chapter deals with biodiversity scoring, this being one of main aspects of this research. After a general introduction about biodiversity, there is an explanation of why it is important for the green space analysis and how the assessment of biodiversity can be performed, especially in an urban area. The most important part of this chapter is the detailed description of the chosen biodiversity assessment method which was adapted for this research. The reasons for choosing it and how the method was made to work for the context of the study location are explained.

This chapter is closely related to Chapter 7, which presents the results, and to Chapter 8 which explains how the results of the biodiversity assessment are taken into consideration in assessing the quality of green spaces. The description of the detailed application of the chosen method also relates back to Chapter 3 about the research methodology chapter and the discussion of the stages of the research.

Assessment of biodiversity is one important way of gaining knowledge and understanding about the current ecological stage of a site or location. The results from such an assessment often become an essential consideration for the development of an action plan and further policy making. This is mainly because over the last decade, biological diversity has not only been a concern for ecologists and environmentalists, but has also become a public preoccupation and political debate (Magurran, 2004).

The introduction of an ecological network into urban areas in Europe as a method of ecology preservation was initially triggered by awareness of the degradation of the natural realm and all its contents, which was part of a concern for the general condition of European biological diversity (R. Jongman & Pungetti, 2004). Furthermore, ecological networks cannot be based entirely upon species distribution data but have to be based on a more general long term strategy, which accounts for species change and dynamics (R. H. G. Jongman et al., 2007). At this point, some ecologically related concepts for human functions, such as ‘carrying capacity’ and ‘ecological stability’, became the basis for the creation of an ecological network (Rob H. G. Jongman et al., 2004).

This research investigation has not revealed any reports about the current, general biodiversity state of the city of Makassar, let alone any detailed reports of each type of green space as identified in this research, or other natural remnants of open space around the city. In order to consider the establishment of any type of network of green spaces it is important to have that knowledge for each typology level, in order to assess the ecological feasibility of the spaces identified. Therefore biodiversity assessment becomes an important stage in this research.

6.1. Overview of biodiversity

Biodiversity is a commonly used term; it is well-known as a factor that contributes to life support and human welfare. Biodiversity is a source of food, clothing, material, fuel, and even drugs (Benedict & Mahon, 2006). Biodiversity is also a determinant of environmental systems that provide multiple benefits and ecosystem services to humans (Cooney, 2005). In addition to basic needs, biodiversity can enhance quality of life (Lawrence & Hawthorne, 2006).

Attention to biological diversity began to intensify after the Earth summit at Rio de Janeiro in 1992 (Kim & Weaver, 1994), where commitment to sustainable development was proclaimed (Humphrey, Ferris, & Quine, 2003) as well as commitment to biodiversity conservation (Mace & Baillie, 2007). The term biodiversity is a contraction of 'biological diversity’ and was first used in 1985 (Lawrence, 2010), but according to Leveque & Mounolou (2003) discussion about biodiversity was already underway by the 1980s. Magurran (2004) has also described topics related to biodiversity that have attracted attention since 1976 and as early as the 1960s, such as discussion on diversity and species diversity measurement.

Biodiversity has been defined in various different ways. However, the Convention on Biological Diversity (Lawrence, 2010) and The United Nations Environment Programme (Magurran, 2004) provide a consistent definition. Biodiversity is defined here as the variations that exist in living things from various resources, including those across the land, marine and other aquatic ecosystems. These also include the ecological complexities that are part of these ecosystems, including species and the interactions between species and their ecosystems.

Biodiversity cannot be merely translated as 'species richness'. This is because biodiversity is not just about numbers but rather the functions and values held by the members and components of an ecosystem. One of the attributes associated with the components of biodiversity is that they can be a determinant of the existence of other components. In addition the value of biodiversity is also related to the scientific and local values where the usefulness of a particular species can be a parameter of the robustness or fragility of a community (Wong, Healey, & Phillips, 2002), while species richness merely accounts for the number of different species living together within an area (Purvis and Hector (2000), p. 212. in Bock & Bock (2009)). Even so, Magurran still maintains that biodiversity is simply "*the variety and abundance of species in a defined unit of study*" (Magurran, 2004, p. 8), at a defined space and certain time (Hubbell, 2001).

Biodiversity is also viewed from different perspectives depending on the background of those who have an interest in it, causing widespread definitions of biodiversity. Most definitions refer to the elements emanating from the genes, species and ecosystems present (Lawrence, Wells, Gillett, & Rijsoort, 2003; Perlman & Adelson, 1997) but biodiversity is also considered as a complete system, which apart from involving these components, is also strongly associated with habitat (Lawrence & Hawthorne, 2006).

Overall, almost all definitions put the emphasis on living organisms as the main component with ecological complexity also being part of biodiversity.

6.2. General biodiversity assessment method

Increasing interest in biodiversity has directed the development of biodiversity inventory techniques and measurement methods. Biodiversity in its most usable form relates to genes, species, and habitats which are functioning as a complete system together with climatic and environmental attributes (Lawrence & Hawthorne, 2006). Practically, it includes all living forms of organisms (Savard et al., 2000). Therefore assessment of any one member of the components should be able to contribute to a general description of a certain community and habitat type.

Assessment of biodiversity happens over a range of diverse dimensions, and is often associated with many stakeholders interested in the state of the biodiversity. This happens because biodiversity involves so many areas of interest, ranging from sociology (Leveque & Mounolou, 2003) to the economic and political (Cooney, 2005). In fact, many groups outside the scientific community have begun to pay attention to the issue of biodiversity due to fears of a rapid degradation (Magurran, 2004). Although it can be viewed from many different areas, the approaches made by each field seem to be interrelated because in principle, all have the common objective of the preservation of the environment and the species therein (Leveque & Mounolou, 2003).

The increasing number of stakeholders interested in biodiversity also affects the method of biodiversity assessment, which varies accordingly. This will be very dependent on the interests of those who define biodiversity and for what purpose the assessment is performed. Perlman & Adelson (1997) argue that most definitions of biodiversity do not reflect the fact that assessment of biodiversity can only be made in the field, because the real biodiversity is a concept that must be explained rather than defined. This could explain why the tools for measuring biodiversity are varied and selection of the best method is dependent on its context and the purpose of the biodiversity assessment. "*No single objective measure of biodiversity is possible, only measures relating to particular purposes or applications*" (National History Museum (2001) in Lawrence (2010, p. 5)).

In general practice, biodiversity assessment comprises both animal and plant species. The form of biodiversity study ranges from analysis of species and higher taxon data of animals and plants (van Jaarsveld et al., 1998); predictive distribution mapping of species richness (Gioia & Pigott, 2000); to various developed methods according to the general theme of the biodiversity assessment and the specimen that becomes the main topic and subject of the assessment (Humphrey et al., 2003). Even more, for the purpose of conservation of endangered species, genetic diversity has also been assessed for genetic resources management (van Tienderen, de Haan, van der Linden, & Vosman, 2002). Areas of coverage also range across both land and water.

6.3. Biodiversity assessment for the urban environment

As more and more people live in cities, restoration, preservation and enhancement of biodiversity in urban areas has become important (Savard et al., 2000). For an urban area, biodiversity appears to be everything which can be found in the patches and corridors that are the remnants of the natural environment. Despite the involvement of many artificial components within the system, it is unwise to think that biodiversity is less important in urban areas. Baines ((1985) in (Gaston et al., 2005)) argues that a small town garden cannot be underestimated in these terms as it can be a rich and valuable sanctuary for a host of wildlife. The engagement with less natural attributes can also be considered as a way the biodiversity system adapts to the urban characteristics. Tzoulas & James (2010) emphasize that the concept of biological diversity develops its attributes, as additional elements are added to over time. It is formed from the integration of the attributes of the physical, aesthetic, and ethical environments and the interactions between all components, including the human.

As mentioned before, different interests lead to different ways of and approaches to assessing biodiversity. Hence observation of biodiversity can be implemented through different terms. **Assessment** is performed to get a description of the biodiversity condition or pattern; **Monitoring** is when change of that condition is to be monitored; **Evaluation** is a stage involving a third party to make judgements about certain aspects of importance; **Valuation** is when the intention is to measure the monetary value of biodiversity; and **Indicator** is a term which refers to a measurable variable among more complex variables (Lawrence, 2010, p. 6).

Biodiversity is an important indicator for urban ecosystem condition. An emphasis can also be placed on plants as the base component of the food pyramid (Alberti, 2008b).

The study of urban biodiversity is relevant for urban ecology assessment along with human-related factors (Tzoulas & James, 2010). This is the background of the biodiversity assessment made by this research, which was undertaken in an effort to see the potential of natural remnants or man-made space in urban areas. In addition to this, having an ecological network is strongly associated with the need to identify locations that could be a component of an ecological patch or corridor. It is important also to note the difference between efforts to see the possibility for the creation of ecological networks and the effort to assess the performance of an ecological network which has been formed. Even an area that seems not to have significant potential because of its lack of biological diversity should be taken into account in the inventory of potential urban spots and corridors. Among the ideal conditions that are expected to be achieved by an ecological network is the creation of a network of ecological areas carrying sufficient quality to be an ecological settlement and habitat. This demands a certain condition in terms of their ability to accommodate the requirements of the species that are expected to grow.

For these purposes, the general description of the biodiversity state is the one required by this research. Therefore, the most appropriate type of biodiversity observation is in the form of assessment.

Several studies on biodiversity, as analysed by Tzoulas & James (2010), show the richness and abundance of certain species or indicator species often become the focus. It is inevitable that a detailed study of biodiversity is important even for urban areas in order to describe the urban habitat accurately, but its implementation is not technically easy. The application will require the involvement of an ecologist and also significant resources as well as time and effort, while the results which are inevitably very detailed may not be necessary in the context of urban areas.

According to Yli-Pelkonen & Niemelä (2005), planners or non-specialists (Ward & Larivière, 2004) may not understand the results from ecological studies that are too complicated. Therefore, there is a need for an ecological method which is not complicated but which can provide a general description of habitat in urban areas that is methodologically accountable. Such a method should not require too much time and should be able to be performed by people who are not necessarily experts in the field of ecology (Tzoulas & James, 2010). This is the approach that was further developed in this research.

6.4. Rapid biodiversity scoring for urban biodiversity

Urban areas are unique and different from natural areas. These are the areas where species, habitat and humans interact (Boothby, 2000). Even if a city area is still dominated by natural remnants, the area will remain distinct from a natural area because of its uniqueness in terms of the often intense human interaction with it. Humans are often said to be the cause of a major threat to biodiversity degradation even though the effects of this degradation will also harm humans in return (Kim & Weaver, 1994).

Assessment of biodiversity for urban areas is often considered as a justification for policy planning and city development when ecological concerns are taken into account. The assessment result will be the basis on which to judge whether a particular type of habitat is better than others and what needs to be done about it in terms of its preservation or even restoration. This also applies to Makassar, therefore, a general understanding of biodiversity is required for making such comparisons.

For this research, an understanding of the biodiversity conditions of each land use type in the study location will help in assessing the potential of the areas in the inventory as green open space areas or areas that are already allocated by local governments as green space or for other similar functions.

One way to carry out such an observation is through using a method of rapid assessment. This rapid method is appropriate for use in urban areas because it is not a detailed assessment for each species but only provides a general idea of the biodiversity condition in urban areas. This is particularly relevant to the various parties that require only general information to compare the biodiversity state of several habitat types that exist in urban areas. In fact, even for natural sites researchers sometimes use macro scale and non-detailed assessment to achieve a global non-specific conclusion (Lawrence, 2010). Efforts to make biodiversity assessment more rapid have also been initiated in areas other than urban areas (Oliver & Beattie, 1996; Ward & Larivière, 2004).

One assessment method for biodiversity in urban areas is the rapid biodiversity assessment (RBA) introduced and developed by Tzoulas and James (2010). This method combines observation of vascular plants and scoring of biodiversity. This method can be performed within a relatively short time, and is simple and applicable to different locations.

6.4.1. Why has RBA been chosen for this study?

This rapid assessment method is very appropriate for use in urban areas such as Makassar, the location of this study. As a very fast growing city, Makassar has several characteristics that suggest this method can be adopted and will produce useful results, namely:

- the diversity of vegetation of different habitat types in urban areas is not as complex as that generally found in natural sites in Indonesia;

- there could be interference and technical obstruction to conducting a detailed assessment;
- a more detailed investigation would be more expensive and the resources for this may not be available;
- coverage by built areas is significant, and this needs to be considered in the assessment method;
- as in other developing countries, a rapid assessment method is needed because there is often a shortage of experts in ecology in tropical countries (Danielsen et al., 2000; Novotny, 2002). At the same time tropical countries tend to have complex biodiversity;
- in Indonesia there is an absence of a systematic system for monitoring biodiversity (Danielsen et al., 2000), especially in urban areas. As of 2010, only 20 of the more than 400 Indonesian regencies have begun to catalogue species in their areas (Simamora, 2010).

Adjustments and changes were made to the RBA because of the local circumstances, as there are big differences between the conditions of the location where this method was developed and tested and Makassar. It was produced in a developed country, the UK, with a temperate climate, whereas the city of Makassar is a tropical city in a developing country.

As mentioned earlier, the rapid method developed by Tzoulas and James (2010) contrasts with conventional methods in terms of the simplicity of its implementation without reducing the accuracy of the results. Table 6.1 shows differences between the conventional methods for biodiversity assessment and the RBA. In Table 6.1 the conventional method is a combination of the characteristics of several assessment types.

Table 6.1. Comparison between conventional biodiversity assessment and the rapid biodiversity scoring of Tzoulas and James (2010)

Conventional method	**Method of Tzoulas and James (2010)**
Requires specific expertise in biology-ecology (Oliver & Beattie, 1993)	Applicable by people with minimal ecological understanding
Implementation could be very intensive because it might require a high level of detail (Ward & Larivière, 2004)	Minimum level of detail as what required is the general description
Requires significant cost and time (Oliver & Beattie (1993); Ward & Larivière (2004))	For its simplicity, cost and time are minimum
Observing species of both animals and plants (van Jaarsveld et al., 1998)	Observing only plants as the main component of urban habitat (apart from humans)
Recording species richness or abundance of species, or indicator species; could be a census or sampling (Magurran (2004); Gordon, Manson, Sundberg, & Cruz-Angón (2007))	Recording the diversity of vascular plants
Vegetation structure is taken as main indicator (Schwab, Dubois, Fried, & Edwards, 2002)	Observing dominance of different vegetation structures
Diverse level of observations; these could be a number and a detailed description of each component of the observed biodiversity (Tomei & Bertacchi, 2006)	Observations produce biodiversity score and possibly description of vegetation structure
Appropriate for areas with complex biodiversity contents such as natural sites	More appropriate for urban areas where biodiversity is less complex and detail output is not necessary

6.4.2. Description of the rapid biodiversity assessment of Tzoulas and James

The method is based on observations and quantification of land cover by different vegetation structures and recording types of vascular plants found at the study sites. The combination of the vegetation structure and diversity of vascular plants produces an overall score of biodiversity at a particular location.

This method was developed after a series of surveys over 4 years (from 2004-2008) which were held at three different locations in the United Kingdom. The three sites represent three different types of land use, namely a network of open spaces in a suburban area (Birchwood Forest Park, Warrington, England), an urban park (Alexandra Park, Manchester, England), and an urban residential areas (Whalley Range, Manchester, England)

6.4.3. How the Tzoulas-James method was performed

The method consists of three main stages as shown below.

1) Development of an appropriate checklist to record the types of urban habitat, vegetation structure and the lists of vascular plant species in the study area.
2) Completion of a list that has been made in the field by combining the Isovist Tandy techniques (Westmacott & Worthington, 1997) and the dominance scale of the land cover (Sutherland, 2006).
3) Using the technique developed by Tzoulas and James (2010), the dominance of vegetation structure and diversity of vascular plant species are combined into a total score of biodiversity.

The stages are described further as follows along with the technical adjustments made in the Makassar study.

6.4.3.1. Development of checklists

There are two checklists used in this study, these being a list of typologies of urban habitat and the list of vascular plants at the study sites.

1. List of urban habitat typology

The list of urban habitat types used by Tzoulas and James when performing this method is an existing list which had been developed earlier from several other studies (Livingstone et al. (2003); Honnay et al. (2003); Freeman and Buck (2003); Pauleit and Duhme (2000) and Freeman (1999); all in (Tzoulas & James, 2010)). For this study it was important to analyse whether the habitat types are relevant to those that really exist in the study site. Adopting urban habitat types from studies in other locations could be too general or too specific. Most importantly, the types of habitat represent heterogeneity in the study location.

For the Makassar study, the urban habitat type is formulated in the form of a typology. This was developed through analysis based on observation of aerial photographs, current land use maps, and documents of previous studies as well as local knowledge about the conditions of the city (see chapter 5). Table 6.2 is an example of a field record sheet used for this Makassar study, which lists all the possible typologies considered. A sample of a completed field record sheet as used in the survey is presented in Appendix 1.

Table 6.2. Field record sheet used for the Makassar study

Typology of space (representation of habitat type) :	
Inter-house space	Commercial space
Un-built spaces	Empty field
Institutional space	Public field **
Public open/green space *	Wetland
Fish pond	Urban farm
Primary roads	Secondary Roads
Tertiary Roads	Rivers
Stream/Canal	In-property Corridor

Vegetation Structure	**Height**	**Domin value**									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
High trees	≥ 10 m										
Low trees	5 - ≤ 10 m										
Bushes	1 - ≤ 5 m										
High grasses and forbs	20 cm - ≤ 1 m										
Low grasses and forbs	5 cm - ≤ 20 cm										
Ground flora	≤ 5 cm										
Aquatic											
Built											

Domin value =	**1:** <4% cover with few individuals;	**2:** <4% cover with several individuals;
	3: <4% cover with many individuals;	**4:** 4-10%;
	5: 11-25%;	**6:** 26-33%;
	7: 34-50%;	**8:** 51-75%;
	9: 76-90%;	**10:** 91-100%
Notes	* : includes cemetery **: includes sport fields and grounds	

Vegetation structure refers to the composition and height variability of trees, shrubs, forbs and grasses in an area (Tzoulas & James, 2010). Domin value refers to the analysis of their dominance assumption based on the land coverage characteristics. It is done by allocating 10 classes for a range of 0 – 100 per cent, although near the bottom of the scale the graduation of the scale is smaller. The value is assessed through visual observation therefore there will be a degree of error in the recording.

Nevertheless, this allows rapid use of the method (Kent & Coker, 1992). In order to minimise subjectivity, wherever possible this assessment was performed by the same individual. In addition, vegetative cover can be measured for each patch using aerial photographs as well as field inventory (Cook, 2002). Therefore, the assessment of dominance level could initially be assisted by the aerial photographs to give a general description of the site and idea of the vegetation coverage. However, on-site observation through field work becomes essential to observe two or more overlapping structures properly.

2. List of vascular plants

In conducting the study in the UK, Tzoulas and James (2010) used a list of vascular plants developed from secondary data for the area they sampled. Their study was facilitated by the availability of such data which could be obtained from relevant institutions and was also accessible on-line. For the Makassar study, such a list could not be obtained either from the relevant government agency or from previous studies. Vegetation data available are limited only to species of trees and some large shrubs. Moreover, if such a plant list is available it might contain only those plants that grow in public places which are managed by the local authority, such as urban parks, road sides and road medians, as well as in state-owned property, so would not be representative of all sites identified in the typology.

In order to overcome the unavailability of a representative vegetation list for this study, the decision was made to do the process in reverse, and use the RBA to start to establish such a list, which would then be useful for other researchers. As a result, this study developed a list based on vascular plant species recorded at the survey locations, and this list is found in full in Appendix 4. An urban surveyor might not have expert knowledge of all types of plants, but using an expert for the RBA would be contrary to the underlying reason for using this method, which is its applicability for use by non-specialists. Therefore, the types of vegetation found were recorded and documented to be further identified if not instantly recognizable in the field.

Tzoulas and James (2010) recorded the genera of vascular plants on the basis of an existing list, while this study recorded all species found during the sampling process. Because the amount of vegetation that cannot be identified was significant, it was impossible to categorize the plants into a specific genus given the species were not yet known. The worry was doing this could affect the score in relation to recorded plants, where bias could occur due to two types of plants that are actually in the same genus being counted as being two distinct genus. Therefore, the diversity of plants was based on the number of vascular plants species and not the number of genera. This will obviously have an effect on the analysis of the results, although the relative ranking of the different typologies will be visible. The analysis method is discussed further below.

6.4.3.2. Assessing land coverage by vegetation structure and diversity of vascular plants

This stage consists of three main activities: determining sample size, number of sampling points, and recording vegetation structure as well as vegetation diversity.

1. Determination of sample size

The size of the sample is determined by selecting an area the size of which is considered sufficient to represent the type and structure of vegetation present in the sampling location. Tzoulas and James (2010) applied a radius of 65 metres after testing several sample sizes in the field and found that this dimension gave the most representative result.

In the event, the Makassar study used a radius of 60 metres based on the observation that this size captures sufficient variability. This size, an 8% reduction of the original RBA, also reduced the number of sampling points to be taken. The 60m radius was decided on by using aerial photographs. This study defined the size of the sampling points by determining a circle size that included most observable different colour densities and surface appearances, assuming that a different appearance is representative of different vegetation coverage characteristics. The intention was to confirm this in the field, and if the 60m radius appeared insufficient or too much, then adjustment was made by adding or reducing the number of sampling points (not by reducing the sample size). This adjustment helped to reduce research costs by reducing the number of field activities, visits and labour hours.

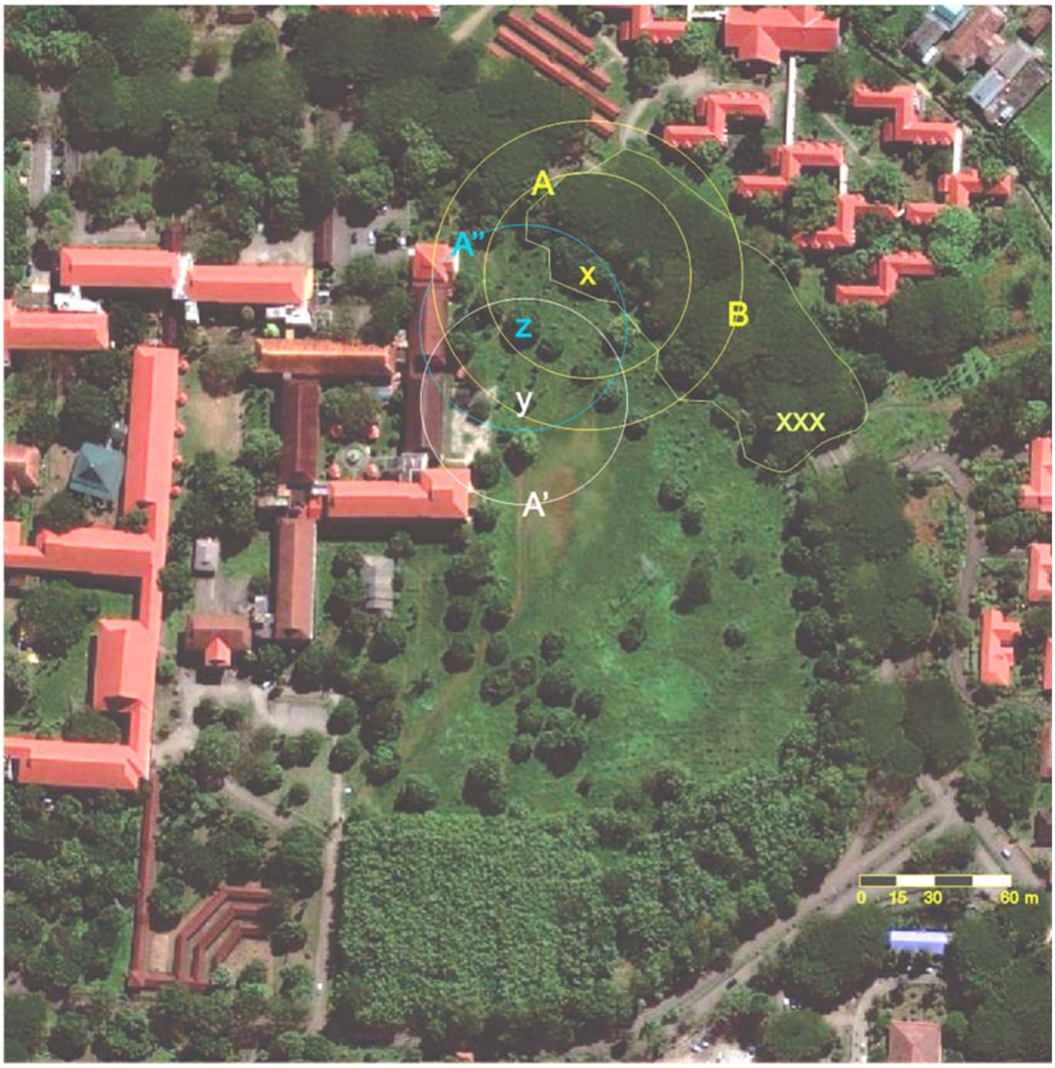

Figure 6.1. Illustration of sample size determination using aerial photographs

The figure above illustrates the two different sample sizes that were tried on an aerial photograph. Both took a tree (x) as the centre of the circle. The circle A has radius of 40m whereas B has a 60m radius. It appears that using the 40m circle means the coverage would only be of green cover and would not touch the built structure. The circle B (60m radius) would cover all types of green coverage visible plus the built structure to both northeast and west sides, thus covering more variety. As a result, this size was chosen. Shifting the 40m radius circle (A circle) towards the built structure (A' circle) by taking tree y as the centre would include some built structure, but would miss other types of greenery such as the mass of trees (xxx). This would result in more sampling points being required to best cover all variability. Even moving the smaller circle to circle A'' with tree z as the centre would only cover a small part of what seemed to be significant greenery (xxx) in the area. Although circle A'' might appear to cover as many variations as the 60m radius could, it still does not adequately cover significant green features to become the main focus of the sampling.

Using the same principle over different locations, a 60m radius became the most appropriate in two main aspects: more variations in land coverage were captured; and the green coverage was kept as the most important variable. Some sites appeared to be small enough to be suitable for a smaller sampling size, however, this study applied the 60m as a constant size throughout all sampling locations. Although in some cases a 50m radius would be just about right, for some sites this 50m radius would require more sampling points. On the other hand using too large a circle size, more than a 65m radius, would not be practicable for urban areas (Tzoulas & James, 2010).

6.4.3.3. Determination of the number of sampling points

The number of sampling points was determined as much as possible by following two main principles: the number represents at least 10% of the site size, and it represents all variability in the site. Again, with the help of aerial photographs, this process was simplified and made faster. If a site visit then revealed that the prescribed number was inappropriate, adjustment was made at the site to fulfil the two principles. Figure 6.2 illustrates how the number of sampling points in a particular location was decided.

In order to make the decision on the number of sampling points in line with the two principles mentioned above, it is important to recognize the variety of land coverage and appearance that needs to be captured. The figure above is an urban farm location in the Makassar study which appears as one matrix. The steps are described as follows:

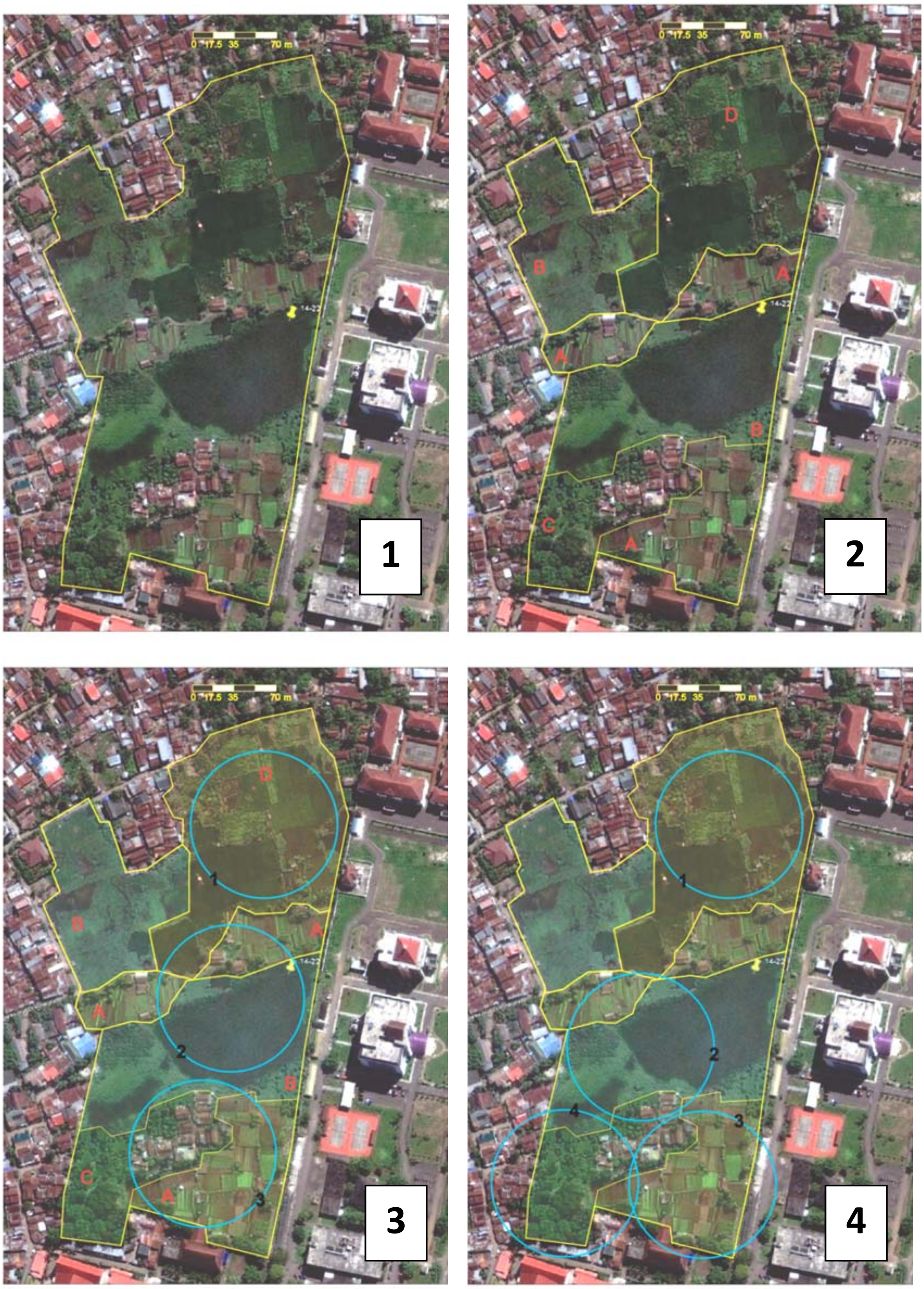

Figure 6.2. Determination of number of sampling points

Picture 1: From the aerial photograph, the boundary of the sampling location is defined.

Picture 2: It is possible to see quite clearly that the location could be divided into several smaller patterns. One pattern seems to be formed by several different size small brown and green rectangles (A), and this pattern is found in three positions. Another pattern, B, looks like a form of watery area, possibly with some low ground cover and aquatic flora. This pattern appears in two locations. The pattern C appears to be a combination of built area and green patch of supposedly higher vegetation, which is quite distinct from the other patterns. The pattern D seems similar to B in terms of the large dark green area, presumably a body of water, with rectangles as in A but bigger in size, therefore making it worth assuming this is a different type.

Picture 3: Having assumed that the location has four different land coverage patterns, it is possible to propose sampling points that include the four patterns to cover all variability. With the 60m radius circle of a sampling point, only three sampling points could be used as the coverage would include all four identified patterns. However, it then transpired that the three sampling points as first planned were not practicable due to the conditions in the field. Sampling point 2 needed to be shifted because of the lack of access to the centre of the sampling point circle (the watery area appeared to be a deep swamp) therefore the centre was moved to a dry area (a makeshift bridge) as the observation starting point (Figure 6.3.). Additionally, although the circle of sampling point 3 covered both patterns A and C, the coverage of pattern C was mainly of the built area leaving the greenery untouched (whereas the greenery is the main focus of the investigation).

Picture 4: Therefore, the final number was four sampling points as they would cover all four patterns properly and their positions were practicable in the field.

Figure 6.3. Determination of observation starting point (centre of sampling point circle) in location, shifted according to site condition.

6.4.3.4. Recording of vegetation structures and diversity of vascular plants

This stage consists of several steps:

1. Defining the visual horizon

The centre of a sampling circle is best placed relative to a specific landmark. This is the mark from which to start the observation in each sampling point. The landmark can be a tree, a built feature, or a post, basically anything that is fixed to the ground. In the UK study (Tzoulas & James, 2010), they needed to have a firm fixed landmark as they performed several visits to each sampling point. Therefore the landmark would ensure they started their observation in exactly the same spot for each visit. For the Makassar study, as the visit was only made once for most of the sampling locations, the landmark could be manually set up if an on-site landmark could not be properly located due to the condition in the field.

With GIS, the landmark could also be determined after laying down the sampling circle, as the coordinate of the centre of the circle fixed the position of the landmark. This could be adjusted by shifting the centre to align it with a certain feature such as a tree, providing that doing this did not contravene the principle of coverage and representation of variability.

Sometimes adjustment took place in field when the reality on the ground differed from the photograph. This is due to the time gap between the date of the aerial photograph and the date the fieldwork was conducted; (the aerial photograph from Google earth was dated July 2010, whereas the fieldwork was performed between July 2011 and January 2012).

The visual horizon was defined for each sampling point. Figure 6.4 illustrates the process of defining the visual horizon and its border. As determined before, a radius of 60m was measured as the distance from the landmark. From the centre of the landmark, eight radii of 60m were set out from centre to north (1), centre to north east (2), centre to east (3), centre to south east (4), centre to south (5), centre to south west (6), centre to west (7) and centre to north west (8). The end of each radius was marked and these marks became the signs that limited the visual observation; these marks were the borders of the sampling point.

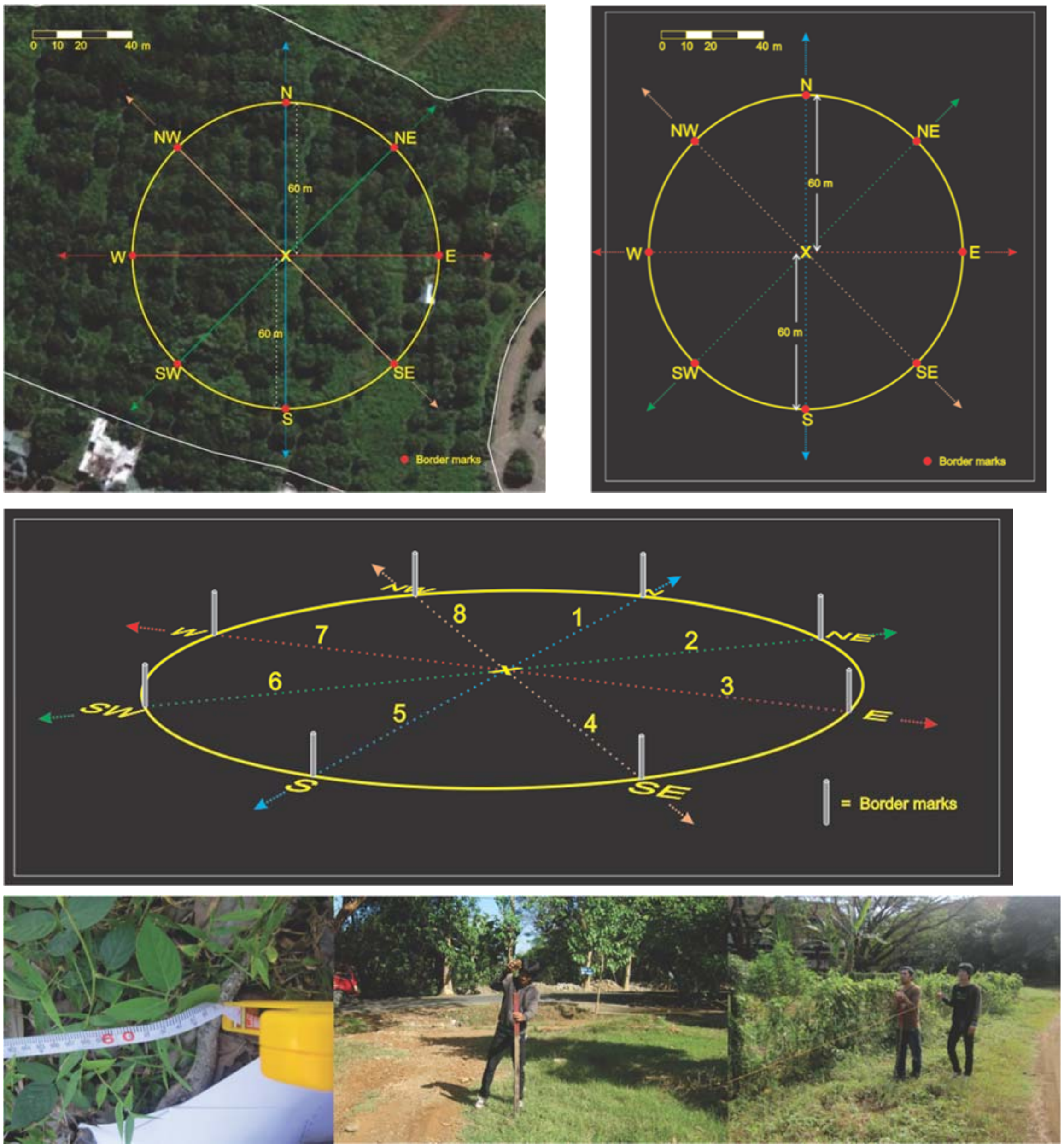

Figure 6.4. Sampling border identification for visual horizon

Determination of sampling point borders could have been achieved more simply with the help of GIS software. The end of each radius can be digitized and the coordinate of each border retrieved. The exact position in the field can then be located with the help of Global Positioning System (GPS). However, due to limited resources, the employment of GIS for this study was only in formulating sampling size and numbers and landmark position. The sampling borders were identified through the field activities, as in the original method of Tzoulas and James (2010).

The need for adjustments to the original method became apparent as experience built up during its implementation. For example, in most of the sampling locations, instead of using a measuring tape and boundary pole to measure and mark the transect lines and borders, this study used footsteps and on-site markers to measure and position the border of the observation area. This change was related to the psychological behaviour of people in a city like Makassar. Local people do not want to see people wandering around near their property with a measuring tape and camera since land ownership is a sensitive issue for people in this area. This adjustment was required as some sampling locations were around or within private properties.

2. Recording dominance of different vegetation structure

The proportion of land cover occurring because of the different vegetation structures was estimated through visual observation and then recorded on the field work sheet developed earlier. Figure 6.5 below illustrates how this stage was performed. Visual observation was made from the centre of the circle (landmark) down to the sampling border by observing all existing vegetation structures. Observation was made in all directions (A-A’ and B-B’ of picture a). This can be achieved when nothing is blocking the view. If any building or high vegetation obstructed the view, the observations were made by walking around the sampling area (as in picture b). The Domin value of each vegetation structure was then recorded.

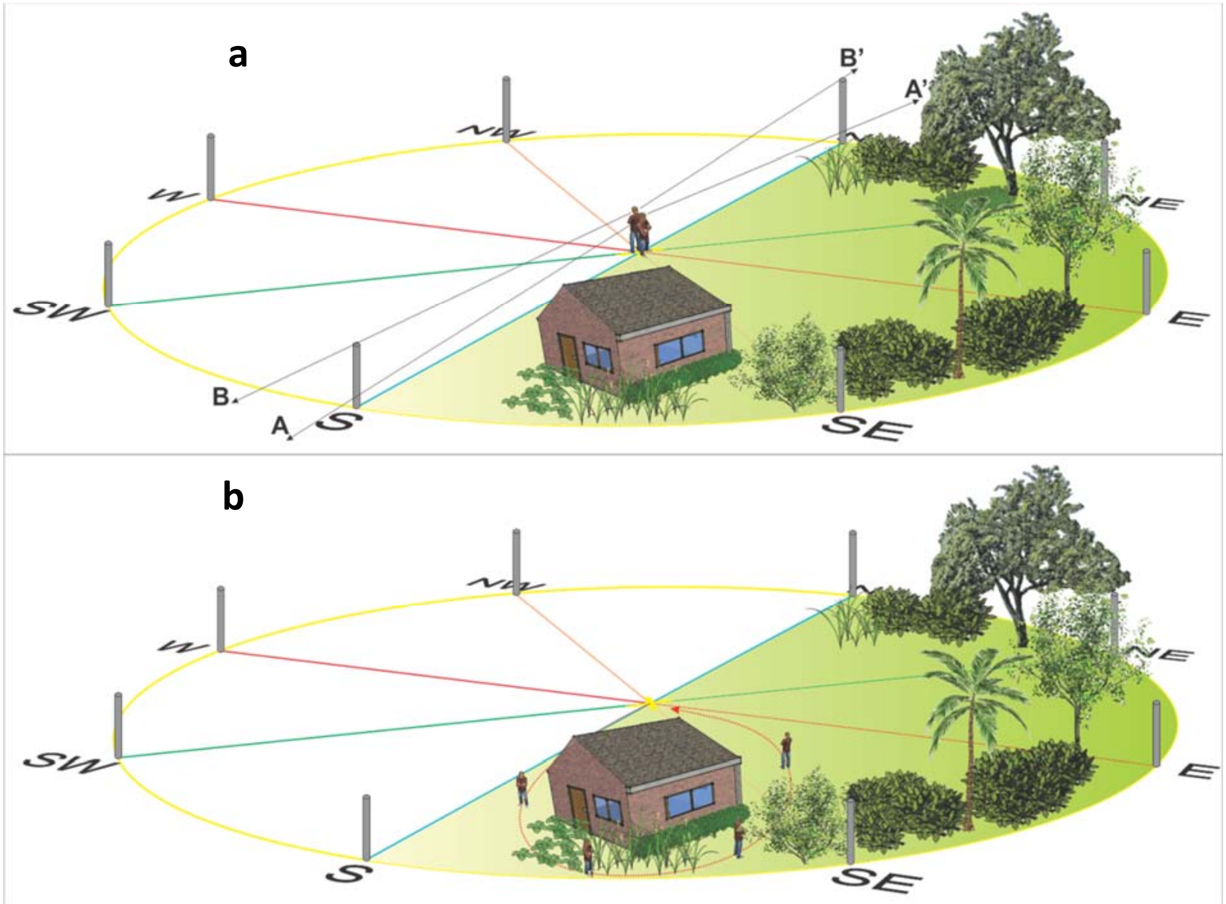

Figure 6.5. Observation of vegetation structure dominance

In addition to observing and recording, this study also captured panoramic images that cover the 360º rotation view. One 180º panoramic image of A-A' and another one of B-B' (as figure 6.6.) were made. These were in addition to the field documentation, and their purpose was to help assess or justify the results of the observations, which could be influenced by observer subjectivity.

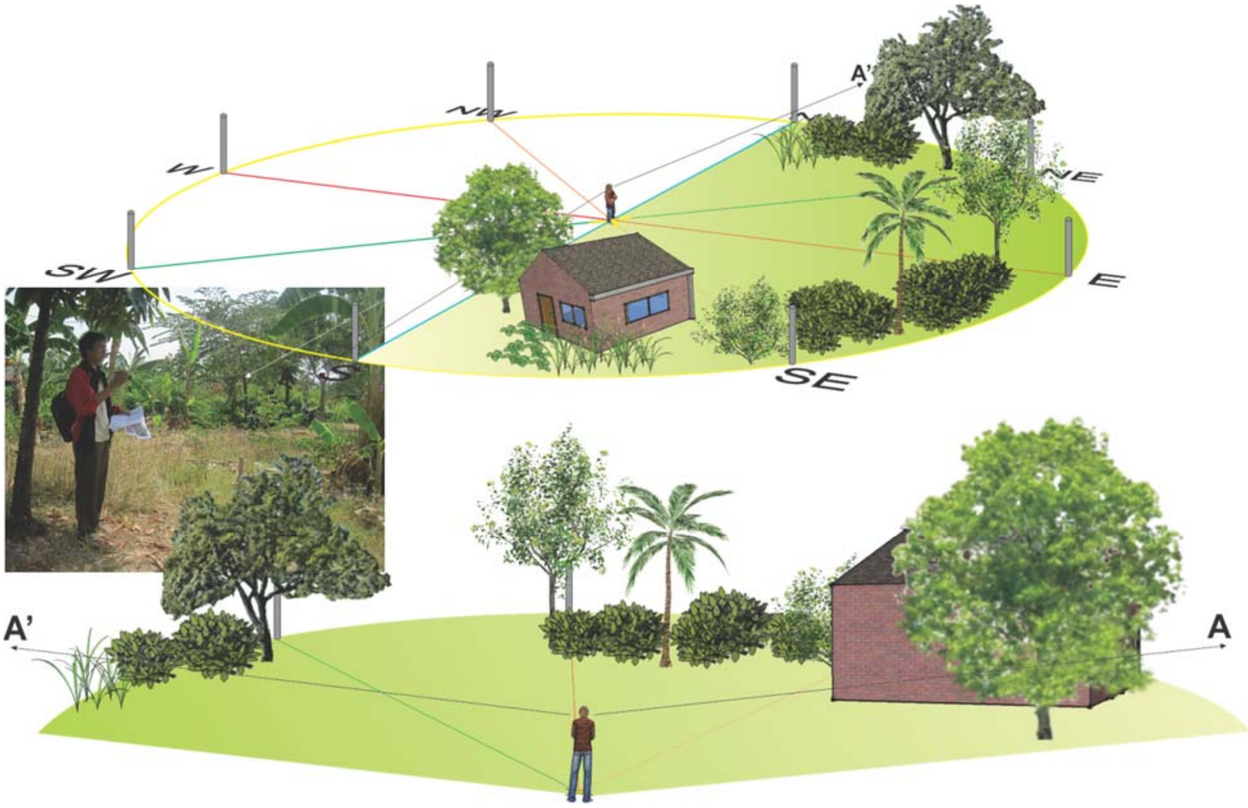

Figure 6.6. Panoramic view observation and capture

Figure 6.7. Panoramic view samples on which determination of Domin value is based

3. Identifying and recording vascular plants

The eight radii, which were defined before in the sampling point determination in the previous stage, were then taken to form four transects by combining every two unidirectional lines into a 120m long line. These lines were then used as the mid line of the transect (Figure 6.8.a and b). Each transect was then made into a path 10 metres wide (5 metres to each side of the line) as in Figure 6.8.c. These are the paths where vascular plant identifications would be made. Each transect (path) was walked four times to record every vascular plant, including the trees, shrubs, grass and ground cover that existed within the transect. The dominating vascular plant of each vegetation structure, or the one that visually stood out, was then identified (Figure 6.8.d). Due to the possibility that some species were not visible or their presence was not dominant or obvious, the recording process might have missed some species. However, it is assumed that this stage had sufficiently recorded the significant vascular plants that have a substantial role in forming the vegetation structure of the area. Unfortunately there was no previous detailed biodiversity study of any surveyed location in Makassar with which to compare the results of this study.

The original RBA method also suggests more than one visit should be made to each of the sampling points to see how things change between summer and winter. Again due to limited research resources, this study only performed one visit to each site. This is, however, justifiable for a tropical location since seasons do not change the vegetation cover to any extreme amount, as happens in the UK where the original method was developed, and nor do the structures of plants change seasonally.

6.4.3.5. Combining indicators into a biodiversity score

This part of the work differed somewhat from the original RBA method because of the changes made to the method as previously described. The following will describe a final score calculation according to the numbered steps used by Tzoulas and James (2010) and how these were adjusted for this study.

- Step 1: Addition of one point for every vegetation structure presence

Without comparing the value of each structure, as long as a vegetation structure was present in the sampling site, one point was added.

- Step 2: Addition of point/s regarding the Domin value of the built area on the site.

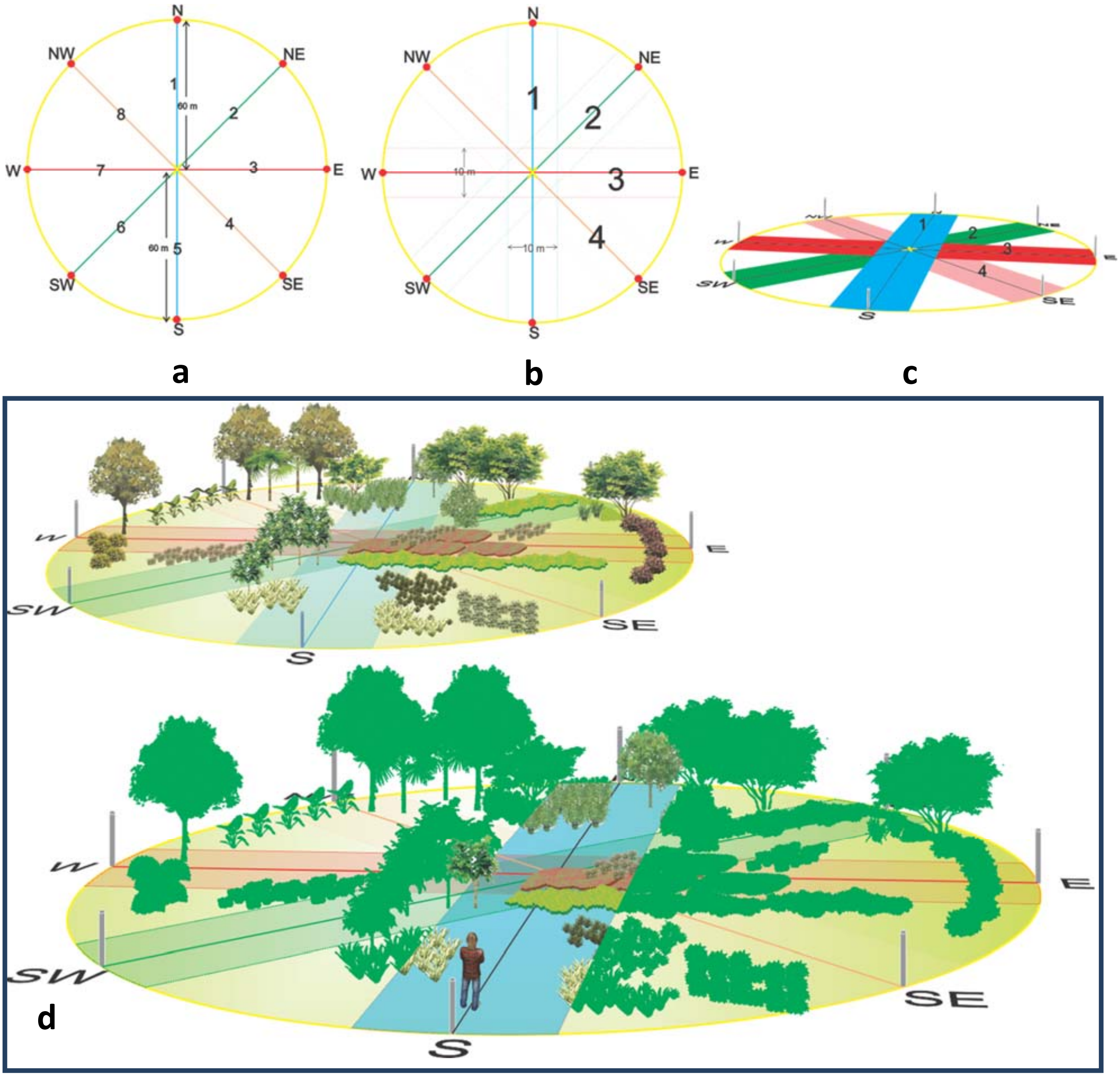

Figure 6.8. Transect set up and vascular plant identification

Areas with less built structure certainly have better potential for greater plant diversity as the presence of built structures will reduce the space for natural components (Godefroid & Koedam, 2007). Therefore, a reduction in points was applied if the sampling location was dominated by the built area. The procedure for addition and subtraction of points with respect to the presence of built structure can be further seen in Appendix 2.

- Step 3: Addition of points relative to a predetermined number of recorded vascular plants

  As mentioned before, due to the unavailability of a vascular plants list in Makassar, this study could not develop a plant genera pre-survey list and therefore had to develop a list based on field observation. However as the types of plants that could not be identified when the field work was undertaken were significant in number, all kinds/species of vascular plants found in the sampling locations were recorded and documented. Therefore the vascular plants were recorded on a species-base, not a genus-base. This gives rise to the possibility two plants were actually under the same genus but each recorded individually. This will be taken into account when the results are analysed.

  The reason for awarding a point in regard to the predetermined range of identified vascular plant genera by Tzoulas and James (2010) was to capture a reasonable variation. A range which is too large will provide less variation, hence the selected range of 6 in the original UK method to separate each point. Although the least number of vascular plants found in one location in the UK study was 13, using this as the range size would result in less variation.

  The vascular plants observed in the Makassar study were species based, and not all species were necessarily recorded but only those which were visually significant within a transect. The least number of vascular plant species recorded for a sampling point in the Makassar study was 6, which coincides with the range applied by the UK study. Therefore, the range 6 was also selected for the study in Makassar. Additionally, using 6 as the break point would provide more variations for the results of a vascular plants inventory. Changing the break point would affect the final biodiversity score, but would not change the relative position of the score among the different sampling locations.

- Step 4: Sum of final biodiversity score

  All scores obtained from each step were summed to get the final biodiversity score.

Complete procedures in the form of tables can be seen in Appendix 2. The results of the biodiversity score for the Makassar study are presented in the next chapter of this thesis.

6.4.4. Scoring for one sampling location

This part describes how the scoring was made for one sample location of the Makassar study. The location is 'Taman Macan', an urban park which is classified as public open/green space. There is only one sampling point in this location, hence it is a good demonstration of how the scoring is made. The raw data obtained from biodiversity assessment in this location is presented in Table 6.3.

Table 6.3. Field data (raw data) obtained at one sampled location: 'Taman Macan' urban park

Sampling point No	Typology group	Vegetation Structures Scores								Number of Vascular Plants
		High trees	Low trees	Bushes	High grasses and forbs	Low grasses and forbs	Ground flora	Aquatic	Built	
52	Public open/green space	8	4	7	0	5	1	1	7	66

- Step 1: As seen in Table 6.3 for the particular sampling point (sampling point 52) there are 7 (seven) vegetation structures present and only one is missing (high grasses and forbs). Therefore the score for this first step is **7.**
- Step 2: The domination value of built structure in this sampling point is 7, and according to the procedure explained above (see Appendix 2) the score for having this value is **-2**.
- The number of obvious vascular plant species identified in this sampling point is 66. According to the range where 1 point is given for every 6 species present, the score would be **11**
- The overall biodiversity score for this sampling location is: 7 + (-2) + 11 = **16**

6.4.5. Appraising the method

Several weaknesses of this method regarding the purpose of this study, which is to assess the potential of each typology as ecological spots and habitat, need further discussion.

- The first weakness is only recording vascular plants without differentiating them as to whether they are indigenous or introduced (exotic). This will affect knowledge about creating an ecological network, since a true ecological network should be based on indigenous species.

- Secondly the different domination of each type of vegetation structure does not reflect the biodiversity score. For example, an area where trees are densely dominant would not score better than area dominated by grasses, since the number of vegetation structures present are the same in the two areas. In fact dense trees would be a better refuge site for some urban birds than an open grassed area (Hadinoto, Mulyadi, & Siregar, 2012).

- The method only accounts for plants and not insects or animals. As well, only vascular plants are identified. However for an urban area, assessing plants is an adequate way to assess the potential for habitat establishment. On the other hand vascular plants are what mainly form vegetation structures, and these are, therefore, a good indicator of biodiversity in general (Cornelis & Hermy, 2004; Gaston et al., 2005; Whitford, Ennos, & Handley, 2001).

As mentioned before, application of the method of Tzoulas and James (2010) for this study in Makassar was only possible with several adjustments. The following table summarises these adjustments

Table 6.4. Adjustments to rapid biodiversity assessment method in Makassar

Description	Tzoulas and James (2010)	Application for Makassar Study	Comments
List of Vascular plants	Data was available and obtained from relevant institutions	Developed from the fieldwork	Such a list was not available from either official sources or previous study
Determination of sampling point size and number of sampling points	Several trials on the field before appropriate representative size was determined	Adjustment based on surface appearance from aerial photograph which was then confirmed by fieldwork visit.	Direct on-site trial would not be feasible due to limited time and resources
Transect and sampling border set up	Using measuring tape and field marker at the boundary	Using estimation by footsteps and on-site markers for the borders.	This is more to comply with people's psychological behaviour due to sensitive issue regarding land ownership
Number of site visits	Several times per sampling site to record possible changes	Once or twice at most due to limited resources and tropical climate	Vegetation structures in tropical climate do not change greatly within short time
Level of vascular plant identification	Listing down to genus	Recording every obvious species whether immediately recognisable or not regardless of the genus	This is the result of not having a guiding plant list, and having to develop a list on the ground.
Addition of a point relative to the number of recorded vascular plants	Based on number of genus	Based on number of species	Due to the fact that some species remain unrecognisable this will affect the score, yet it is still practicable to compare scores using species-based scoring

Pointing especially to the addition of points relative to the number of recorded vascular plants, the original UK study (Tzoulas & James, 2010) did this based on the number of genus of vascular plants, whereas the Makassar study was based on number of species. Again, this is due to the fact that some species remained unrecognised prior to the final scoring stage. This will affect the final biodiversity score compared to when the numbers of genus are used, but since there is no maximum and minimum score, it is still possible to compare scores with species-based scoring. Using species instead of genus will not change the trend in presumed biodiversity richness among different sampling locations, as it is possible to consider an area with more vascular plants species ‘richer’ in plant biodiversity as well as for an area with more recorded genus.

In fact, making an inventory down to the level of species could be better in terms of understanding biodiversity function. Different species even within the same genus may have different roles in the ecosystem. This happens because different plant species despite being in the same genus may have different vegetation structures. An example is one species found in the study sites: *Mimosa pudica*. This plant, known locally as 'puteri malu,' is commonly used as an indicator of ecological succession in grassland areas. This particular plant is a kind of ground cover, but has relatives in the same genus that are shrubs, such as *Mimosa rubicaulis*, *Mimosa turneri*, and even trees, such as *Mimosa tenuiflora*, *Mimosa pigra* and *Mimosa cineraria* L, which is also known as *Prosopis cineraria*. This is commonly what is meant by the term 'diversity of species'

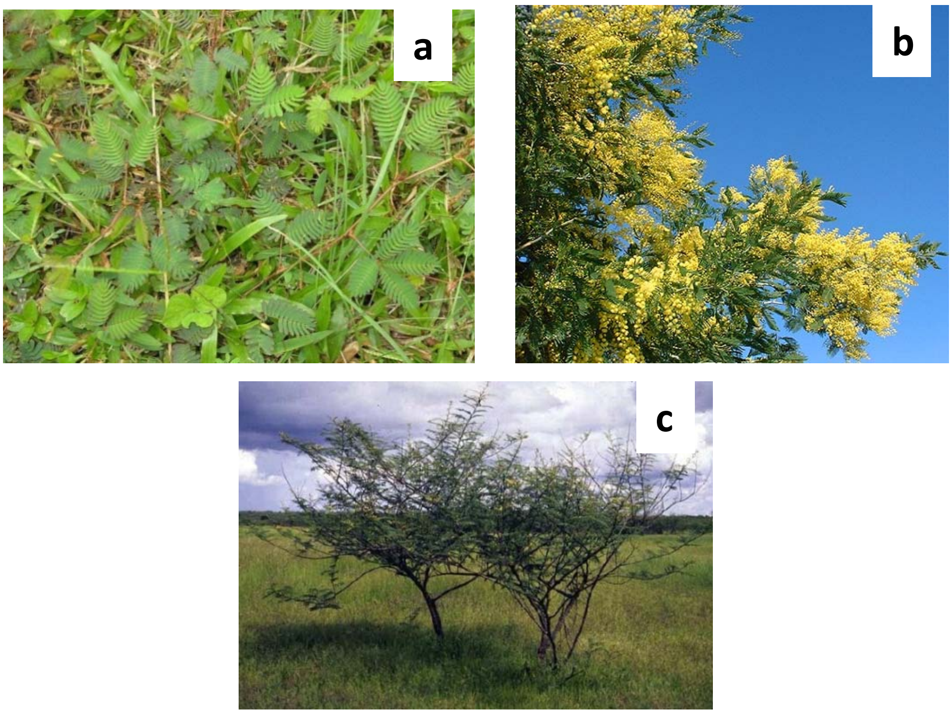

Figure 6.9. Plants belonging to the genus *Mimosa*; examples of plants that are in the same genus, but have very different habitus: a. *Mimosa pudica* (ground cover); b. *Mimosa rubicaulis* (shrub) and c. *Mimosa pigra* (tree)

Differences in structures will lead to different functions and roles for these plants although they are in the same genus. Trees would serve a different function in an ecosystem compared to ground covers. This is a common situation in plant taxa because a single genus may have a vast number of species (Richardson, Pennington, Pennington, & Hollingsworth, 2001). Knowledge of the species level could help in making assumptions about the condition of the areas where these plants grow because science is more familiar with the term indicator species rather than indicator genus.

Diversity can even occur down to a lower level in taxa, such as the genetic diversity of plants within same species (Satelite, 2011; Templeton, 1994), and biodiversity can be assessed at different levels of organization from genetic to ecosystem (Pearson, 1994).

6.5. Summary

In this chapter it is important to note that the use of the term biodiversity refers to plant biodiversity as well as to the biodiversity assessment method (RBA) adapted for this study. The detailed description of how the RBA was adapted to a tropical climate and developing city situation should be sufficient for it to be applied to a city with similar conditions and background to Makassar. Most of the adjustments relate with the technical applications for making this method work on the ground. The big difference between the original and the adapted RBA was in scoring species of vascular plants rather than genera, although the same relativities should still be apparent in the final score. The RBA also does not account for differences between exotic and native plants, although in an urban area dominated by human beings, like Makassar, this may be of lesser importance. This is an area for further research, although this study has started to contribute to this by using the adapted RBA fieldwork as the start of generating a list of identified plants found in Makassar.

Chapter 7

Biodiversity Assessment Results

Use of the adapted RBA for biodiversity assessment as described in Chapter 6, resulted in scores for each sampling point, with the sampling points representing different types of typology. This chapter presents the results with additional necessary physical description of each typology.

7.1. Plant biodiversity of spaces according to typology group

Biodiversity assessment using the rapid scoring method was performed on several sites in the study area which, according to the priority analysis of the typology group, were categorized as high and medium. In addition, for low priority sites, such as inter-house space, assessment was also conducted at limited locations in order to understand whether the assumption made in the priority analysis was concordant with their biodiversity state.

However, the commercial space typology was a group of sites that could not be surveyed. Not only is the typology low in priority but there are also difficulties in having access to this type of site. Apart from that, ground observation suggests that commercial spaces are very unlikely to be managed in any shared way with government as part of a network of green spaces due to their current lack of greenery and high possibility for development and conversion. Moreover, although the Ministry of Public Works has described spaces within commercial and business sites after any development as a type of open green space (Minister of Public Works, 2008), it is still difficult to enforce such regulation.

The regulation determines open green spaces within shops and business grounds should be allocated according to a basic coefficient of building coverage (area occupied by all built structures). What the coefficient looks like is not obvious. What is stated is that as much as possible open spaces should be provided and at least two trees should be grown; if this is not possible, plant containers should be added. However in practice this type of space has never been seriously taken into account by the municipality as an area that might be part of urban green areas. Neither has any known standard been forcefully imposed on business owners. Therefore this regulation appears more of a suggestion than a regulation.

Apart from commercial space which was not surveyed as explained above, the whole river corridor was also not surveyed. It was assumed the biodiversity of river corridors would be represented by the sampled locations of fish ponds and wetlands, which are situated by the riverside.

Although in-property corridor was also identified as a potential corridor in the typology, none were sampled in the fieldwork. This was due to observations in the field that this type of corridor is similar to the tertiary road type. This happens because the vegetation of tertiary road corridors, which was originally thought to be either growing along the roadside or in the median strip, is usually formed by vegetation growth within house yards and other private properties. So in principle these two types of corridors are not different, or in other words, tertiary roads can also represent in-property corridors.

Rapid Biodiversity Assessments (RBAs) were performed in 29 locations throughout Makassar at 74 sampling points. The distribution of all sampling points can be seen in Figure 7.1. For any particular location there might be more than one typology as identified in this study, and therefore each separate typology needed to be investigated accordingly. For example in an area which, according to the government, is identified as a neighbourhood of residential areas, this study identified several types of typology because, despite being within the boundaries of a residential area, their physical appearance, vegetation cover, and current use are different.

The number of sampling points for each location differed depending on the variety of vegetation cover and structure but not depending on the size. However for locations with a clear boundary and land-use type, this study tried as much as possible to survey at least 10% of the area with the scoring method developed. This is also reflected in the number of sampling spots for each typology group. There are types of typology that cover huge areas, but according to pre-assessment using aerial photographs and pre-visits, are quite homogenous. For these, this study took a small number of sampling spots as opposed to certain other typologies which cover relatively smaller areas but that are more heterogeneous, with more varieties of vegetation structure and cover.

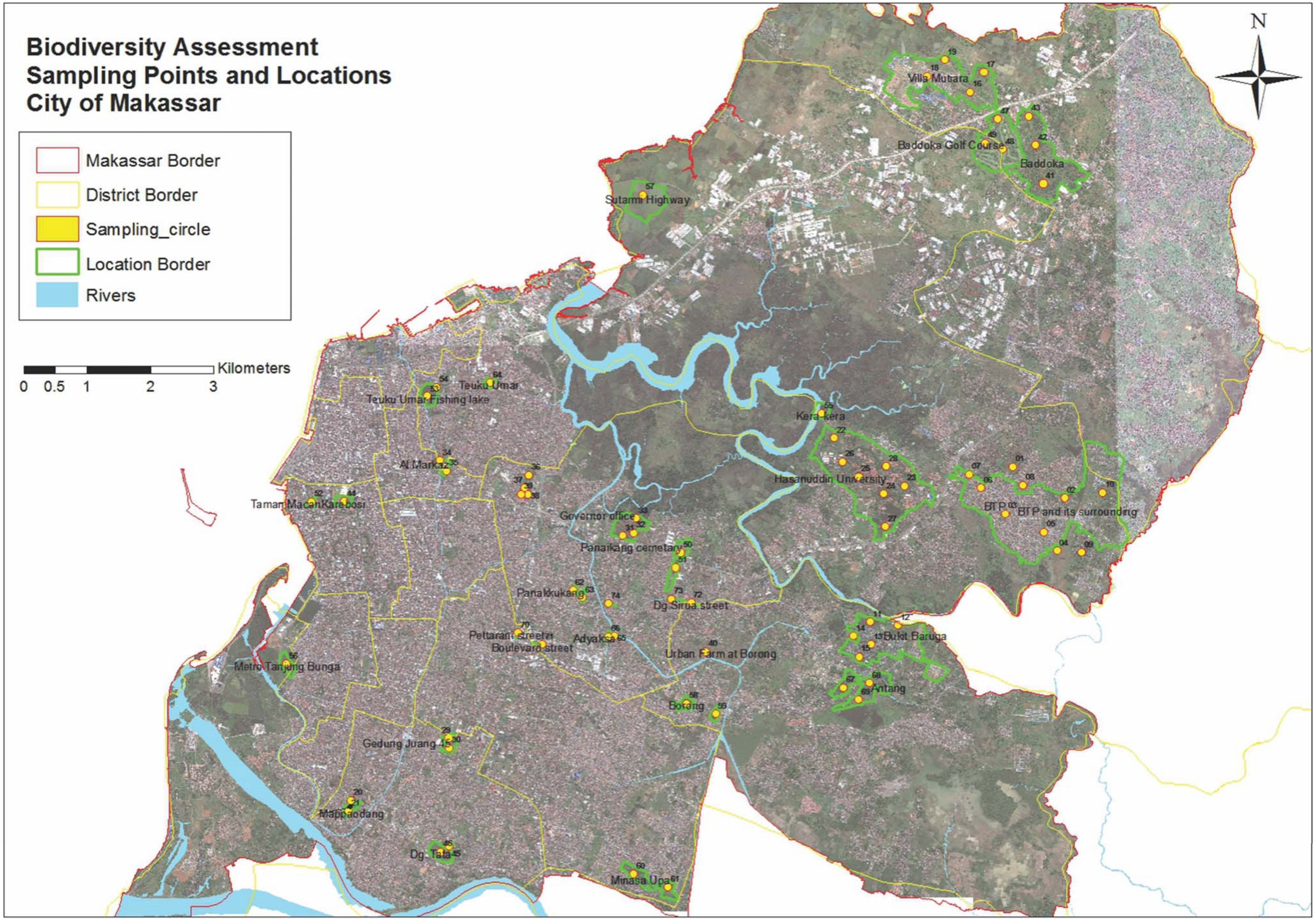

Figure 7.1. Distribution of sampling points and locations in Makassar

The relationship between number of sampling points and plant biodiversity score is further explained in Section 8.1.1

Typology groups which tend to appear homogenous are fishponds, wetlands and roads, whereas the most heterogeneous typologies are urban farms, empty fields and public green space. Some typologies have more sampling points than others; this not only indicates heterogeneousness but is also possibly due to the abundance of these groups throughout the city.

Description of biodiversity assessment and scoring of each typology is presented below.

7.1.1. Urban farm

As a growing city, Makassar has little space left for urban agriculture and farming. Most places where people grow agricultural products are located in the fringe and only few are within the city area. Biodiversity assessment was performed on 11 sampling points in 5 locations. Locations of sampled urban farms are shown in figure 7.2.

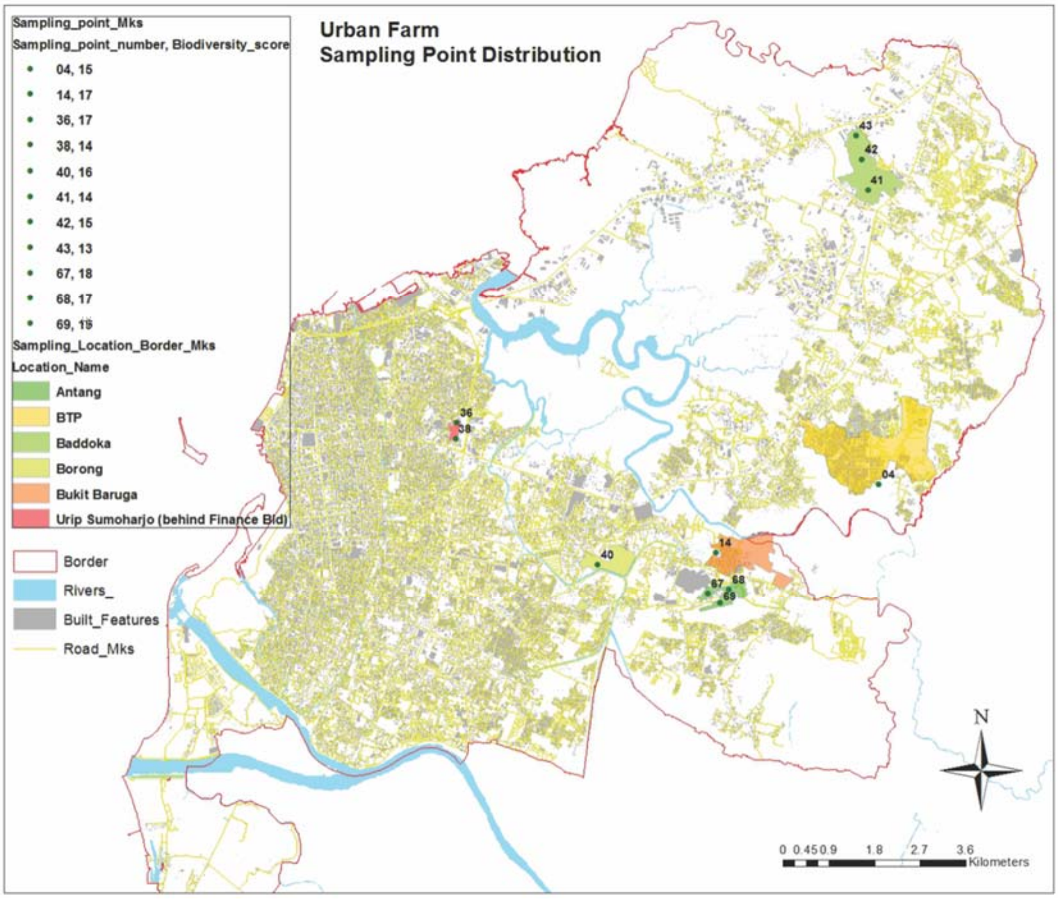

Figure 7.2. Distribution of sampling points for urban farms surveyed

The Biodiversity scores of each sampling point are presented in Table 7.1.

Table 7.1. Biodiversity score of each urban farm sampling point

Location Name	Sampling point No.	Vegetation Structures Scores								Number of Vascular Plants	Bio-diversity score
		High trees	Low trees	Bushes	High grasses and forbs	Low grasses and forbs	Ground flora	Aquatic	Built		
South of BTP (Paddy Field)	04	1	1	2	0	7	1	2	1	18	15
Bukit Baruga	14	1	1	2	6	7	0	1	2	34	17
Urip Sumoharjo (behind Finance Bld)	36	5	2	2	1	2	2	5	2	27	17
Urip Sumoharjo (behind Finance Bld)	38	3	2	4	2	3	3	1	6	42	14
Borong	40	2	2	3	3	3	9	5	3	30	16
Baddoka	41	8	5	4	3	6	5	0	0	17	14
Baddoka	42	7	2	2	3	5	2	0	1	15	15
Baddoka	43	4	1	2	2	7	2	0	0	11	13
Antang	67	8	7	7	7	6	7	0	0	41	18
Antang	68	6	3	3	2	2	4	2	0	25	17
Antang	69	1	1	3	5	6	1	2	1	32	19
Total		46	27	34	34	54	36	18	16	292	**175**
Average		4.18	2.45	3.09	3.09	4.91	3.27	1.64	1.45	26.55	**15.91**

As seen on the map, most urban farms are in the fringe of Makassar. There are some farm spaces more towards the centre of the city although the areas are not significant in size. These spots are remnants of previous large agricultural fields which have been degraded to make way for infrastructure development, thus when it comes to their status they are likely to be converted in the future. Almost all urban farms visited are privately owned, or under collective ownership, and some are even unclear as to whether they are on private or state land. Their status could have an effect on the possible conversion in the future. The following figures illustrate the appearance of selected urban farms in Makassar and the vegetation structures captured in panoramic photographs.

Figure 7.3. Two urban farms in Makassar (Source: Google earth, 2010)

Figure 7.4. Panoramic views of three urban farms in Makassar

Sites with agricultural uses have been recognized as the dominant proportion of landscapes in many countries including Indonesia (R. H. G. Jongman et al., 2007), perhaps explaining why agriculture can still be seen in these countries' cities.

Civilizations have modified natural landscapes causing the resulting agricultural landscape to contain only small isolated patches of natural habitat (Hilty, Jr., & Merenlender, 2006). On the other hand, agriculture sites are often mentioned as a cause of the fragmentation of natural patches (Anonymous, 2000; Krisp, 2002; Pattanavibool, Dearden, & Kutintara, 2004). The development of standardised agricultural fields is seen as a cause of the reduction in landscape structure diversity (Vuilleumier & Prélaz-Droux, 2002). In particular this is the case in suburbs or rural areas where more green areas generally dominate the land cover. However, according to Pullen (1977) agricultural fields are a valuable resource that should be retained for productive use.

For areas such as Makassar city, where green spaces are limited, the existence of land that is still a working urban farm is a potential to be utilized in creating a green network, and such spaces need to be maintained accordingly.

Agriculture is a cultural field where human activity is dominant; therefore, the potential disruption to the natural system is quite high. Besides, the vegetation structure is dominated by agricultural crops and cultivated plants, which together are not agents for the components of a natural ecological habitat. In other words, the urban farm, as seen at all the visited sites, has low potential in terms of habitat function. Yet, urban farms in Makassar still have functionality value as green areas, assuming that they can be preserved from land conversion. This is because the diversity of vegetation is quite high as seen from the recorded vascular plants (although some of these are cultural rather than natural). At several locations in Antang (such as the one in Figure 7.5), the urban farm type has good tree coverage, and hence the usual environmental services provided by trees may still be obtained (Chiesura, A (2004); Nowak, Crane, & Stevens (2006); Nowak (1993); and Singh, Pandey, & Chaudhry (2010)).

Over all the surveyed urban farm sites, low grasses and forbs are dominant. Enclosure by trees was the second dominant structure of the urban farm type. The average biodiversity score of urban farms in Makassar is 15.91, the highest among all typologies. This is mainly due to the absence of built structures and the presence of various vegetation structures. An urban farm type which occupies significant area in Makassar is the paddy field. Although not only for rice, paddy fields are closely associated with wet rice farming. A report on wetlands (Puspita, Ratnawati, Suryadiputra, & Meutia, 2005) outlined the significance of paddy fields as habitat for various plants and animals. Some of the plants found in surveys of paddy fields in Indonesia are for human consumption such as *'kangkung'* (*Ipomoea aquatica* Conv.), '*Genjer*' (*Limnocharis flava* Limn), and '*Semanggi*' (*Marsilea crenata* Mars).

Figure 7.5. An urban farm where dense trees are still preserved

Paddy fields are also an important ecosystem for some animal species. In most Indonesian paddy fields various species are deliberately cultured for human consumption, mostly fish such as 'Bandeng' (*Chanos chanos*), 'Mas' (*Cyprinus carpio*), 'Tawes' (*Puntius javanicus*), 'Nila' (*Oreochromis niloticus*) and various edible crabs. Other common animals in paddy fields in Indonesia are frogs, some reptiles, some species of birds and small mammals (Suriapermana & Bogor, 1994). Varieties of river fish are also found in paddy fields as they are connected to rivers through irrigation lines. These fish, apart from being cultivated for consumption, also help to predate insect larvae which are potential pests as well as increasing soil fertility through their wastes (Puspita et al., 2005).

Although generally urban farms in Makassar have been strongly influenced by human intervention making them highly cultural and less natural, their high plant biodiversity score and status as green areas mean there is great potential for their inclusion in any green or ecological network for the city.

The inclusion of urban farms into a network of green spaces for the city should be considered strategically. The introduction of wildlife-friendly farming is not the only strategy, especially when human green space amenities are put in front of biodiversity. Approaches involving social scientists and ecologists could deliver a more holistic way of directing land-use change for this typology type (Mattison & Norris, 2005).

7.1.2. Wetlands

Apart from the area around rivers, wetlands are also found close to residential areas in a few locations in Makassar. This is not due to the deliberate creation of wetland areas by settlements but rather because many settlements in Makassar are built on what were previously water catchment areas (Tato, 2010).

Table 7.2. Biodiversity score of each wetland sampling point

Location Name	Sampling point No.	Vegetation Structures Scores								Number of Vascular Plants	Bio-diversity score
		High trees	Low trees	Bushes	High grasses and forbs	Low grasses and forbs	Ground flora	Aquatic	Built		
Urip Sumoharjo (behind Finace Bld)	37	2	1	3	8	5	5	8	1	18	16
Teuku Umar	53	1	1	2	0	3	1	4	2	28	16
Teuku Umar	54	1	2	2	1	3	1	5	1	25	18
Borong	58	1	0	1	1	1	2	8	6	19	10
Borong	59	1	1	3	5	4	2	6	1	22	17
Minasa Upa	60	6	4	4	5	2	2	10	0	27	17
Minasa Upa	61	0	0	1	1	1	1	10	0	11	12
Panakkukang	62	1	7	5	2	1	1	2	4	19	14
Panakkukang	63	3	2	1	1	8	1	4	6	28	12
Total		16	18	22	24	28	16	57	21	197	**132**
Average		1.78	2.00	2.44	2.67	3.11	1.78	6.33	2.33	21.89	**14.67**

Wetlands surveyed in this study are in 5 locations. Referring to the types of wetlands (Wetlands International, 2012), those surveyed are floodplains, shallow lakes/ponds, and marshes/swamps. Other types of wetland located around estuaries and coasts were not surveyed, as in both areas the vegetation structures are not very varied, being dominated by mangrove plants like Nypa palm (Alongi (1987); Hardiman (2008)), as found in many Makassar rivers towards their estuaries. Moreover, because these other types of wetland are often characterized by general properties which are not specific to location, information about their biodiversity should be able to be gained from research papers or other related studies.

The following figure shows the distribution of surveyed wetlands in Makassar.

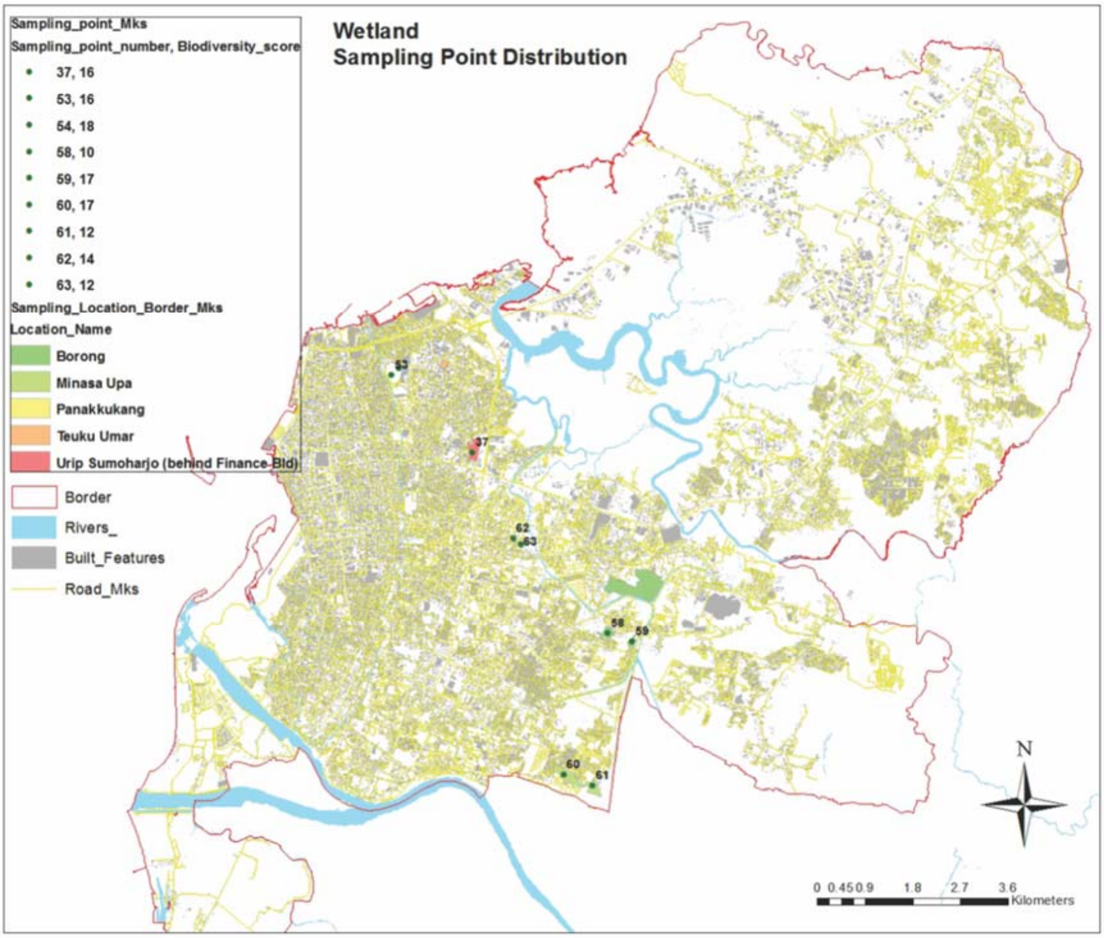

Figure 7.6. Distribution of sampling points of surveyed wetlands

Swamp areas alongside main river corridors and estuaries were not surveyed due to technical difficulties and possible danger to the surveyor, and the fact their existence in the typology has been represented by river corridors, as they are more closely associated with these rather than wetlands. Similar to typical wetlands in Indonesia, the marshlands in Makassar are mostly an area between permanent dry land and permanent water bodies. Their main characteristic is having temporary or permanent shallow water with vegetation coverage of over 10% (Khiatuddin, 2003).

The following are images of surveyed wetlands in Makassar.

Figure 7.7. Wetlands in two different locations, urban fringe (above) and around residential areas (below).

The definition of wetlands according to Wetlands International (2012) is not easy as they can both be land and water, or either seasonally. Therefore their definition depends on the interests of those dealing with the wetland.

Biodiversity assessment in this research identified a range of 11 to 28 vascular plant species in several wetland locations throughout the city. Diversity of both plants and animals in wetlands indicates the environmental quality of this type of land use (Gelt, 1997).

The biodiversity of wetlands in general according to studies in Asia, including Indonesia, is quite various and rich. Observation in both natural and artificial wetlands has revealed plant types ranging from emergent aquatic macrophyte, submergent aquatic macrophyte, and floating plants to trees (Puspita et al., 2005). Animal species commonly found are different kinds of birds which nest in plants and trees around wetlands, reptiles that breed and live in the swamp and various types of fish living in the water column. Water birds such as herons, egrets, ibises, ducks, gulls and terns are observable in swamp ecosystems (Bhushan, Sonobe, Usui, Kai, & Bureau, 1993).

Wetlands in Makassar are also found in the form of water catchment areas. For this type of wetland, biodiversity observation was mainly at the edges of emergent and visible submergent plants. The biodiversity should be richer if all non-vascular and non-visible plants were also included, as studies in Jakarta water catchment areas identified varied water vegetation structures as well as various taxa of animals such as fish, water birds, reptiles, amphibians, molluscs and various zooplankton (Gultom, 1995; Suwidah, Krismono, & Ismail, 2002).

Such a level of biodiversity might not be present in Makassar's wetlands at the moment, although the information from these other areas suggests that improvement could be initiated in an effort to obtain biodiversity-rich wetlands for the city.

7.1.3. Institutional space

There are 4 locations at different institutions where plant biodiversity assessments were made. The sampling locations represent different types of institution, namely campus ground, government office, religious institution, and private business.

Overall, sampling points in the campus grounds have a better biodiversity score than the other locations. They also have more recorded vascular plants and the fact that there are more sampling points in this location reflects the diverse vegetation coverage they have, also obvious in the aerial photograph.

Table 7.3. Biodiversity score of each institutional space sampling point

Location Name	Sampling point No.	Vegetation Structures Scores								Number of Vascular Plants	Bio-diversity score
		High trees	Low trees	Bushes	High grasses and forbs	Low grasses and forbs	Ground flora	Aquatic	Built		
Telkomas	08	5	4	3	1	1	1	0	8	38	11
Hasanuddin University	22	5	1	9	7	7	5	0	1	35	18
Hasanuddin University	23	9	1	2	0	7	7	0	4	56	18
Hasanuddin University	24	9	8	6	8	0	0	0	8	59	12
Hasanuddin University	25	4	0	5	5	10	6	0	4	50	17
Hasanuddin University	26	8	7	1	0	10	1	0	4	35	14
Hasanuddin University	27	7	9	5	4	10	9	0	5	52	17
Hasanuddin University	28	7	6	4	0	9	4	0	8	82	17
Gedung Juang 45	30	2	4	4	3	7	5	0	3	33	16
Governor Office	31	9	7	6	0	9	2	0	4	36	14
Governor Office	32	9	1	1	1	2	2	0	4	22	13
Governor Office	33	4	7	4	0	6	5	0	5	12	9
Al Markaz Al Islami	34	7	5	3	1	7	2	1	9	45	9
Al Markaz Al Islami	35	2	4	3	1	6	2	0	1	32	18
Total		87	64	56	31	91	51	1	68	587	**203**
Average		6.21	4.57	4.00	2.21	6.50	3.64	0.07	4.86	41.93	**14.50**

Different types of institutions lead to landscapes that look different. Offices of both government and private institutions tend to have well landscaped grounds with designed garden areas and tidily mown lawns. Certainly they are designated to support the amenity values of beauty and having exotic plants to please visitors, workers, and employees. This is understandable since research has confirmed that having a view of a garden and greenery has a positive psychological effect which could enhance work performance (Iswoyo, 2003). This leads to the fact that such institutional spaces are less likely to serve as an ecological habitat, yet as green spots they could still provide benefit, mainly for human interest.

On the other hand spaces in higher educational institutions, such as campus grounds, appear to be more 'natural' in the sense that at certain spots which are 'no-go' areas of the campus, vegetation grows in a more natural way, landscapes are less or even not designed, and soil surfaces are dominant. The campus grounds of Hasanuddin University for example, still have significant areas of this type. The existence of dense high trees and vegetation are the reason this campus ground has been officially designated as part of the Makassar urban forest (Antaranews, 2010).

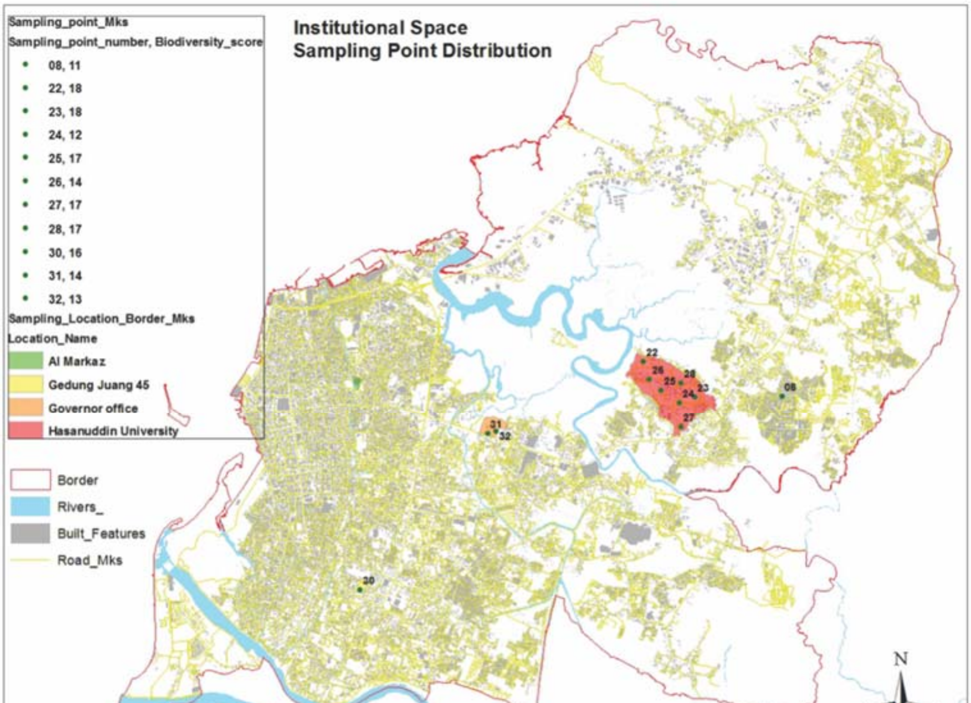

Figure 7.8. Distribution of sampling points of institutional spaces surveyed

The following are images of some institutional spaces.

Figure 7.9. There could be 'less-designed' spots within institutional space, as seen in the campus ground (top), yet most are more 'designed' green spots (middle and bottom).

7.1.4. Empty field

According to the State of Environment Report, 2010, empty spaces in Makassar are recognized as one type of neglected space which forms a significant area throughout the city. Together such spaces are 11.6% of total area which is destined be open green space and their total area is almost half of all vegetated open green space of the city (Makassar City Council, 2010). This indicates a great opportunity is offered by these spaces if the authority can optimize their potential.

Table 7.4. Biodiversity score of each empty field sampling point

Location Name	Sampling point No.	Vegetation Structures Scores								Number of Vascular Plants	Bio-diversity score
		High trees	Low trees	Bushes	High grasses and forbs	Low grasses and forbs	Ground flora	Aquatic	Built		
North_of_BTP	01	1	1	7	3	7	2	1	1	27	18
BTP	02	6	4	8	0	1	3	0	6	22	9
BTP	03	4	2	4	0	1	1	0	8	20	7
BTP	07	1	1	2	5	7	1	0	8	22	8
NHP	09	5	3	8	2	1	1	0	0	27	16
Gedung Juang 45	29	1	4	5	2	2	0	0	4	51	17
Dg Tata	45	9	7	9	6	8	6	0	6	39	13
Dg Tata	46	0	0	9	0	9	6	0	2	26	13
Teuku Umar	64	9	7	7	4	4	3	0	2	26	16
Adyaksa	65	7	6	6	6	6	6	6	1	45	21
Adyaksa	66	8	7	7	7	6	7	5	1	42	20
Total		51	42	72	35	52	36	12	39	347	**158**
Average		4.64	3.82	6.55	3.18	4.73	3.27	1.09	3.55	31.55	**14.36**

Empty spaces, which are state land in most developing cities in Indonesia, are land that without proper utilization could potentially accrue unwanted uses such as squatter communities, where illegal huts and stalls are built for makeshift homes and business stands. Therefore, the authority of Makassar needs to set up plans for these spots for the sake of green city action.

Some other private fields are left empty for significant time without any sign of development as land use conversion is expected occur in the future. Privately owned empty fields like this should be looked at for their possibilities for use as green space by persuading or compensating the owner to do this.

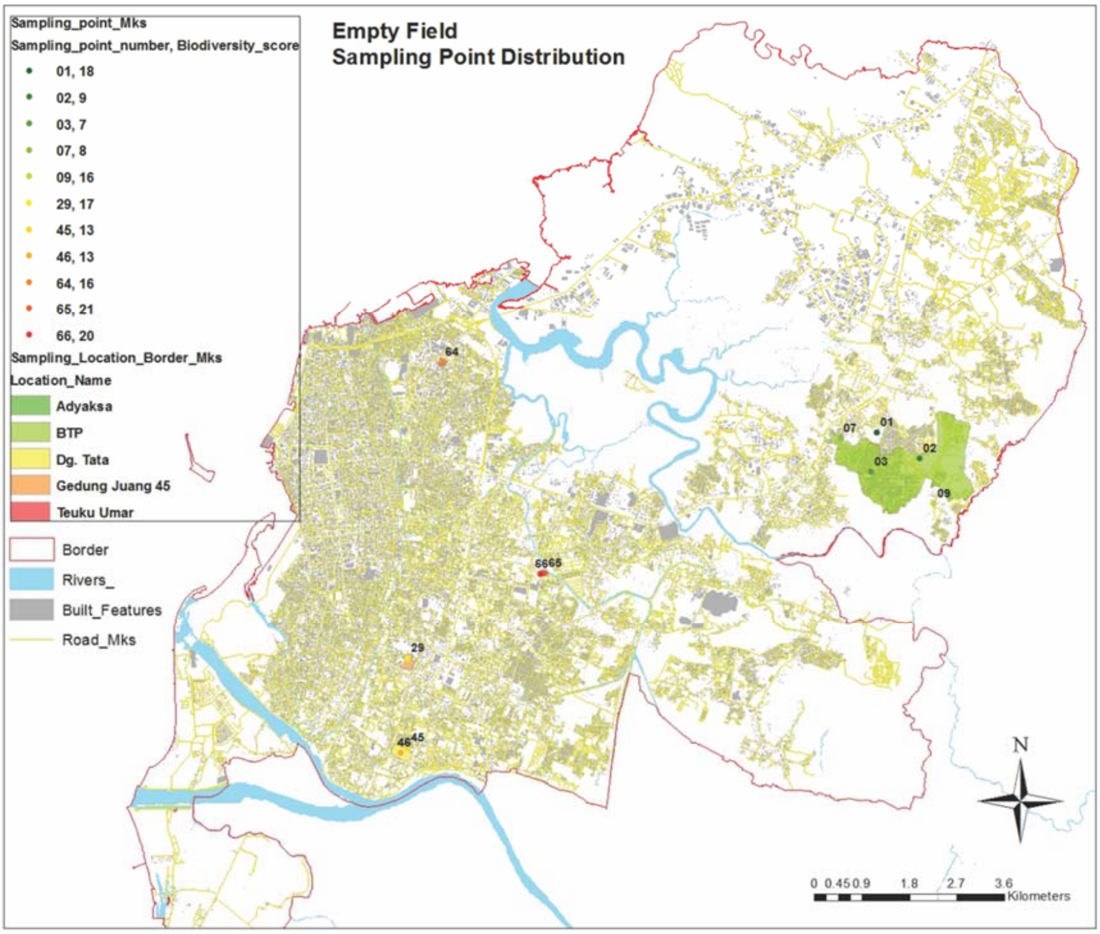

Figure 7.10. Distribution of sampling points of surveyed empty fields

The following are images of some empty field locations

Figure 7.11. Empty fields around Makassar

7.1.5. Un-built space

The assessment of un-built spaces mostly happened in residential complexes which are still growing and all the assessed points are likely to be converted in the future

Table 7.5. Biodiversity score of each un-built space sampling point

Location Name	Sampling point No.	Vegetation Structures Scores								Number of Vascular Plants	Bio-diversity score
		High trees	Low trees	Bushes	High grasses and forbs	Low grasses and forbs	Ground flora	Aquatic	Built		
BTP	10	2	1	5	1	9	1	1	1	19	17
Villa Mutiara	16	5	4	7	1	9	1	0	5	33	14
Villa Mutiara	17	1	1	4	0	9	2	0	0	16	13
Villa Mutiara	19	2	1	1	0	10	1	0	1	17	14
Mappaodang	21	2	4	8	0	1	1	0	6	19	9
Total		12	11	25	2	38	6	1	13	104	**67**
Average		2.40	2.20	5.00	0.40	7.60	1.20	0.20	2.60	20.80	**13.40**

Having performed an assessment prior to biodiversity scoring as well from the observation of characteristics, similarities were found between empty fields and un-built space. Therefore it seems it might not be necessary to have them as separate typologies. The similarities in character can be seen from the average biodiversity score which is similar for both. However, there are also differences.

One way that empty fields and un-built space differ is that the latter occur in locations where development and land conversion is certain to happen, such as in residential complexes or business/commercial centres. Additionally, as defined in Chapter 5, there are differences between the two typologies which strengthen the idea of considering both separately. These were confirmed during the fieldwork. First, un-built spaces are mostly adjacent to houses or commercial buildings and roads or public space, not surrounded by buildings and have openness on at least two sides. In contrast empty fields are not immediately associated with a particular building or property, have open access from at least one direction or are in a form of standalone space. Secondly, an empty field tends to be more varied in its vegetation structure, whereas un-built spaces tend to be open grassed areas. Last is the likeliness for conversion due to status and ownership. It might still be possible for an empty field to be utilized in line with any government program to control green space in the city while it seems impossible to retain un-built space from conversion and building development.

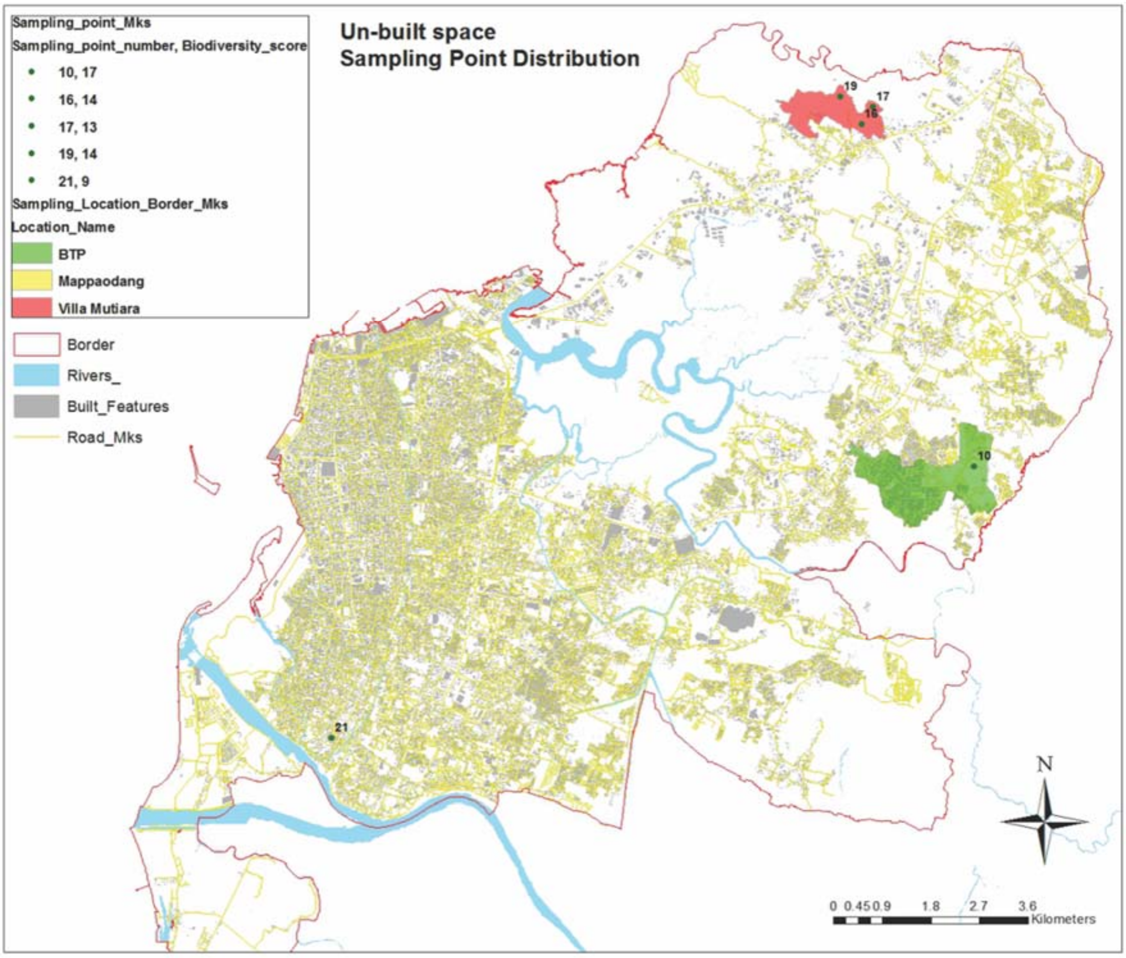

Figure 7.12. Distribution of sampling points of surveyed un-built spaces

The following are images of some un-built spaces.

Figure 7.13. Un-built spaces in two residential complexes in Makassar

7.1.6. Public open/green space

Locations where public green spaces were surveyed comprised both state land and privately managed space belonging to a residential complex.

Table 7.6. Biodiversity score of each sampling point of public/open green spaces

Location Name	Sampling point No.	Vegetation Structures Scores								Number of Vascular Plants	Bio-diversity score
		High trees	Low trees	Bushes	High grasses and forbs	Low grasses and forbs	Ground flora	Aquatic	Built		
Bukit Baruga	11	10	2	1	0	4	1	0	1	14	14
Bukit Baruga	12	6	1	2	1	7	1	5	1	24	17
Bukit Baruga	15	9	5	3	0	5	2	0	8	59	13
Urip Sumoharjo (behind Finace Bld)	39	7	4	5	4	4	5	0	6	35	12
Baddoka Golf Course	47	4	2	2	1	6	2	0	0	18	14
Baddoka Golf Course	48	6	3	1	1	10	1	0	1	20	16
Baddoka Golf Course	49	7	4	3	1	9	2	4	0	24	16
Panaikang	50	5	4	2	1	2	1	0	9	25	8
Panaikang	51	5	4	2	1	2	2	0	9	8	5
Taman Macan	52	8	4	7	0	5	1	1	7	66	16
Total		67	33	28	10	54	18	10	42	293	**131**
Average		6.70	3.30	2.80	1.00	5.40	1.80	1.00	4.20	29.30	**13.10**

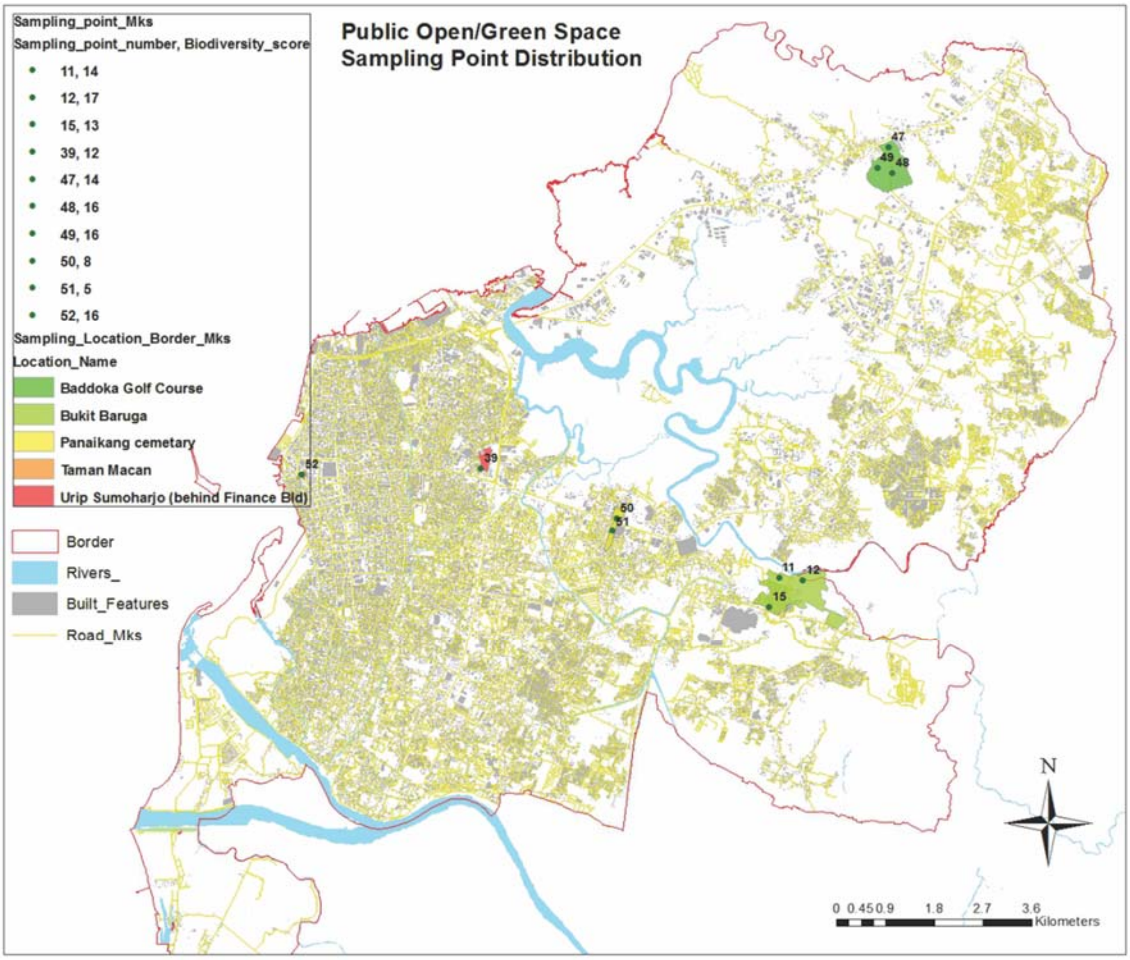

Figure 7.14. Distribution of sampling points of surveyed public/open green spaces

Figure 7.15. are images of some public/open green spaces

Before the field work and as reflected in the priority analysis it was thought that public green spaces would perform well in terms of biodiversity. However, the survey in 5 locations only produced an average plant biodiversity score that was lower than scores for empty field and un-built space.

Understanding the characteristics and observing most spaces of this typology around Makassar, it is apparent that all green open spaces, especially public ones, are mostly located within areas of human activities. They are surrounded by hard surfaces such as pavements and infrastructure elements and other hard and artificial materials. These are features that when present in significant proportions lower biodiversity scoring.

Figure 7.15. Three locations classified as state-land public/open green spaces: golf course (top), public cemetery and urban park (middle), whereas the two bottom pictures are a mango orchard and deer conservancy project, which belong to a privately managed residential complex.

7.1.7. Fish pond

Similar to most fish ponds in Indonesia, the ones in Makassar are artificial ponds filled with brackish water from estuaries, or salt water when located in coastal areas. These ponds in Makassar are mostly used for growing milk fish and shrimps.

Table 7.7. Biodiversity score of each fish pond sampling point

Location Name	Sampling point No.	Vegetation Structures Scores								Number of Vascular Plants	Bio-diversity score
		High trees	Low trees	Bushes	High grasses and forbs	Low grasses and forbs	Ground flora	Aquatic	Built		
Kera-kera	55	1	1	6	1	1	1	7	1	16	16
Metro Tanjung Bunga	56	0	0	2	2	1	1	5	0	6	11
Sutarmi Highway	57	0	0	1	1	1	1	4	0	6	11
Total		1	1	9	4	3	3	16	1	28	**38**
Average		0.33	0.33	3.00	1.33	1.00	1.00	5.33	0.33	9.33	**12.67**

Most fish ponds, including those in Makassar, are artificial wetlands mostly constructed in river catchment or coastal areas, so their ecological standing is very similar to that of other river or coastal areas (Puspita et al., 2005). The converse of this is one reason the biodiversity assessment results for fish ponds are considered representative of that of river-side areas (corridors) in Makassar, as significant areas in these corridors have been overtaken by fish ponds. As an artificial human-controlled ecosystem, the biodiversity is poorer than in natural river and coastal areas. From three locations of sampled fish ponds in Makassar, the range of identified vascular plants is from 6 to 16 species. These are visible plants on the water surface or those growing on dykes.

According to Puspita, et al (2005) combining fish ponds and mangroves will increase the ecological function. This approach would optimize fish ponds as habitat for various water plants and animals, while still retaining value for food production. The biodiversity of fish ponds as reported by Pudjiatno & Ranoemihardjo (1993) consists of various flora ranging from lower classes such as phytoplankton and algae to higher vascular plants such as mangroves. As a cultural patch, most fauna are cultured fish and shrimps, although wild reptiles, small mammals, amphibians and birds are also found. These wild animals are not wanted as they could predate or feed on the cultured fish or shrimps.

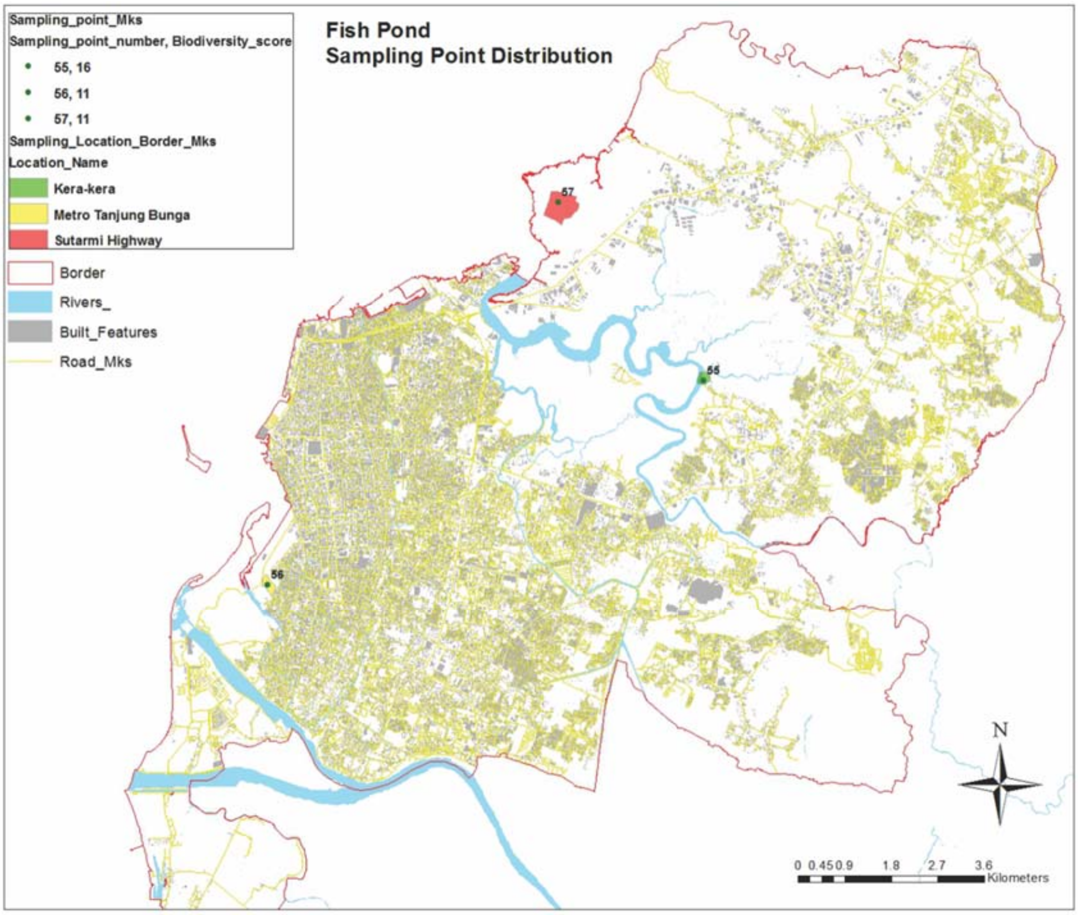

Figure 7.16. Distribution of sampling points of surveyed fish ponds

Figure 7.17. Fish ponds at two surveyed locations in Makassar

7.1.8. Stream/canal

Branching out from the main river, several streams run across Makassar. In order to utilise the streams as conduits for flood control, most have been transformed into artificial canals with concrete embankments.

Table 7.8. Biodiversity score of stream/canal sampling point

Location Name	Sampling point No.	Vegetation Structures Scores								Number of Vascular Plants	Bio-diversity score
		High trees	Low trees	Bushes	High grasses and forbs	Low grasses and forbs	Ground flora	Aquatic	Built		
Dg.Sirua_street	72	6	1	5	6	0	5	1	6	27	11
Total		6	1	5	6	0	5	1	6	27	**11**
Average		6	1	5	6	0	5	1	6	27	**11.00**

This study surveyed one stream location where the banks have not been reinforced with concrete, a rare occurrence in Makassar. The one chosen is considered the least artificial when compared to others which generally have no opportunity for utilization as a corridor due to human settlement and activity right up to the edge of the canal.

In this location, stream and road run alongside each other without sufficient space between for a viable corridor in which to grow plants, and especially trees. According to the Indonesian National Standard (2003) there should be 5.0-5.5 m of clear roadside for utilities and pedestrian use in housing road networks, let alone higher class roads such as secondary roads (like the one in Figure 7.18). These require a wider space if a proper ecological or even a green corridor is to be part of the road

Figure 7.18. Panoramic view of surveyed stream/canal in Makassar

Most streams and canals in Makassar are canalised concrete conduits as seen in Figure 7.19. Not only lacking space for growing vegetation, the local authority is even struggling to keep them clean and unpolluted.

Figure 7.19. Common appearance of streams and canals in Makassar
Source: Makarama (2012)

Canalisation of streams reduces the biodiversity by giving less opportunity for species to persist. Populations of fish could be 31% less and the macro invertebrates population could decrease up to 78% in canalised streams compared to natural streams (Redding & Midlen, 1990).

It is an unfortunate fact that most streams in Makassar are canalised and the chances of increasing their ecological value are very small. Having clean and unpolluted stream water creates a ‘fertile’ environment which could result in significant biodiversity. According to some studies in other Indonesian cities, in ideal conditions streams could harbour different types of emerged and submerged plants as well as various kinds of animals from zooplankton to fish and frogs (MacKinnon, Hatta, & Halim, 2000; Suryadiputra et al., 1999).

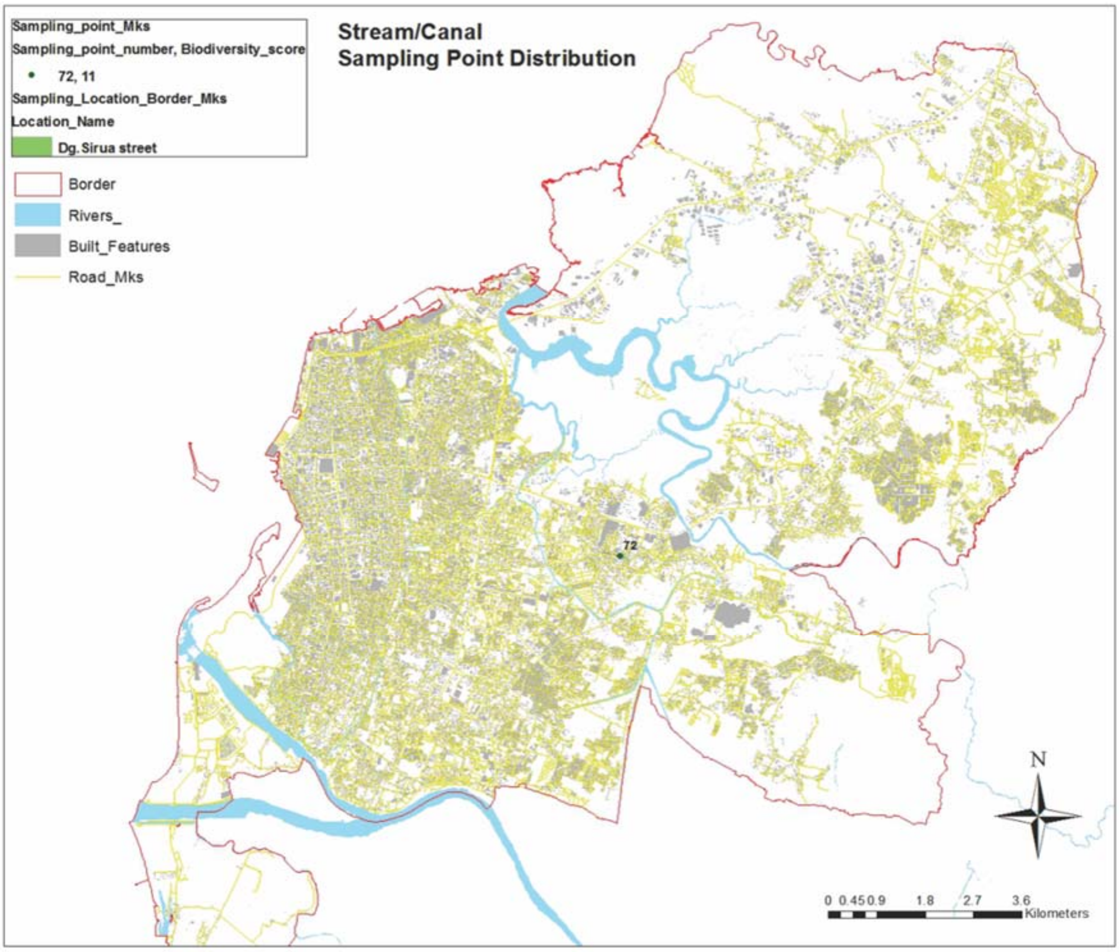

Figure 7.20. Location of a sampling point of stream/canal surveyed

7.1.9. Public field

Table 7.9. Biodiversity score of public field sampling point

Location Name	Sampling point No.	Vegetation Structures Scores								Number of Vascular Plants	Bio-diversity score
		High trees	Low trees	Bushes	High grasses and forbs	Low grasses and forbs	Ground flora	Aquatic	Built		
Karebosi	44	5	0	1	0	9	1	0	4	17	10
Total		5	0	1	0	9	1	0	4	5	**10**
Average		5	0	1	0	9	1	0	4	5	**10.00**

This study only visited 1 public field location, as from the vegetation coverage observations, public fields are all alike and tend to be bare. The surveyed one is the most vegetated and is a state-managed public space. Consequently its condition is well maintained and preserved. On the other hand, public fields near residential areas are actively used for sporting activities by people in the neighbourhood, leaving little or no provision for vegetation existence.

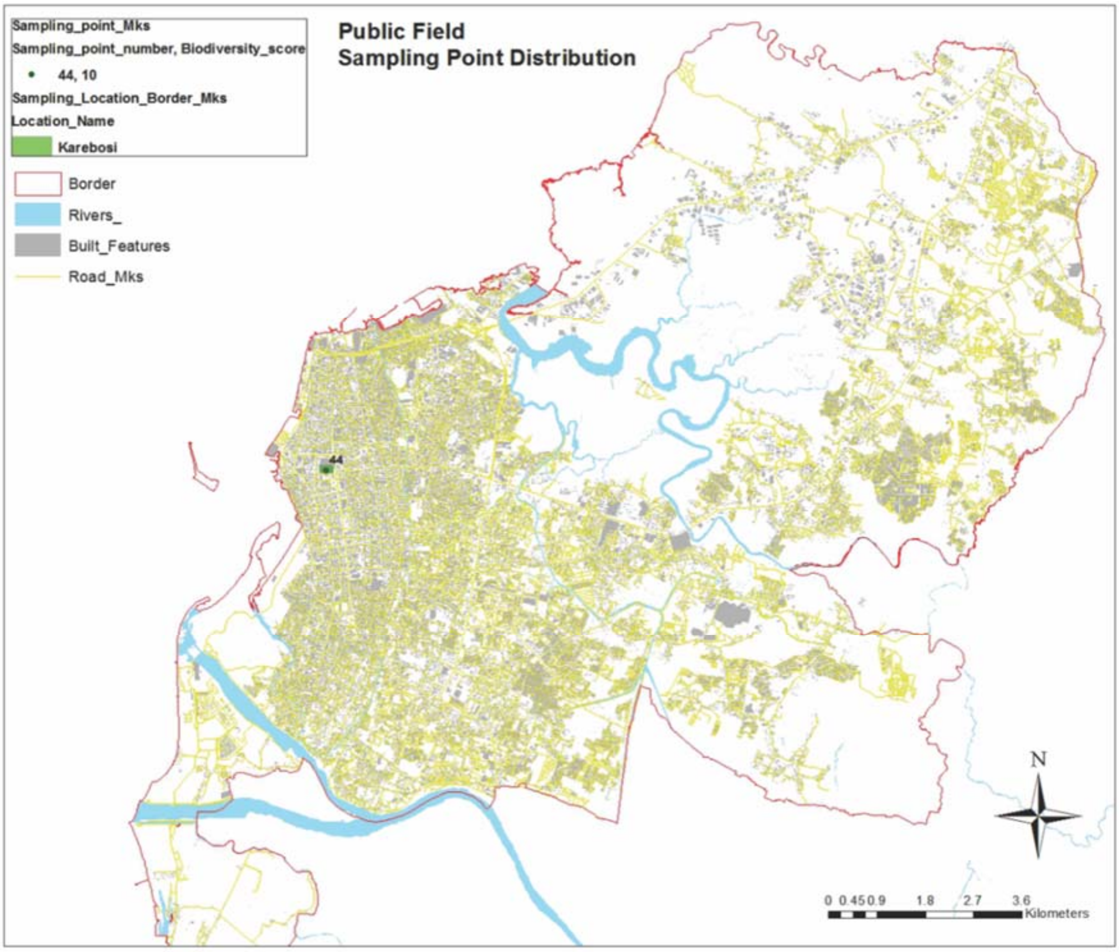

Figure 7.21. Location of surveyed public field in Makassar

Figure 7.22. Panoramic view of Karebosi, the most popular public field in Makassar

Most public fields as seen in Figure 7.22 are sporting grounds. Although Karebosi is well maintained and preserved, the existence of plants does not occur to the extent required for an ecological spot due to the lack of variation in vegetation structures and the high level of human activity in the area.

7.1.10. Inter-house space

This typology is basically another name for domestic gardens, although it includes spaces around houses even if they are not necessarily designated for a garden. The analysis made in this study prior to determining priority for field work (see Chapter 5) gave inter-house spaces a low priority. However, because of the significance in terms of the amount of this type of space in Makassar, it was decided to survey more than one location. In fact, three residential complexes were surveyed, but not all spaces within these locations are considered to be this typology.

Table 7.10. Biodiversity score of inter-house space sampling points

Location Name	Sampling point No.	Vegetation Structures Scores								Number of Vascular Plants	Bio-diversity score
		High trees	Low trees	Bushes	High grasses and forbs	Low grasses and forbs	Ground flora	Aquatic	Built		
BTP	05	1	1	2	0	1	1	0	10	15	4
BTP	06	1	1	4	0	1	5	0	10	40	8
Mappaodang	20	5	4	6	0	7	6	0	7	52	13
Total		7	6	12	0	9	12	0	27	107	**25**
Average		2.33	2.00	4.00	0.00	3.00	4.00	0.00	9.00	35.67	**8.33**

Houses within residential complexes appeared to have more of this type of space available than areas of single family owned houses, and such complexes are more accessible once permission has been granted by the developer. Figure 7.21 shows the location of the surveyed inter-house spaces in Makassar.

According to Gaston, Warren, Thompson, & Smith (2005), total green spaces in urban areas in some developed contexts could be enlarged substantially by the presence of domestic gardens, therefore preservation of biodiversity at the household level could have significance for the biodiversity at the city level. This could also apply in developing cities, including Makassar, as the amount of domestic garden space in the city is enormous. However, specific study of these resources was beyond the scope of this project and forms an area for further research.

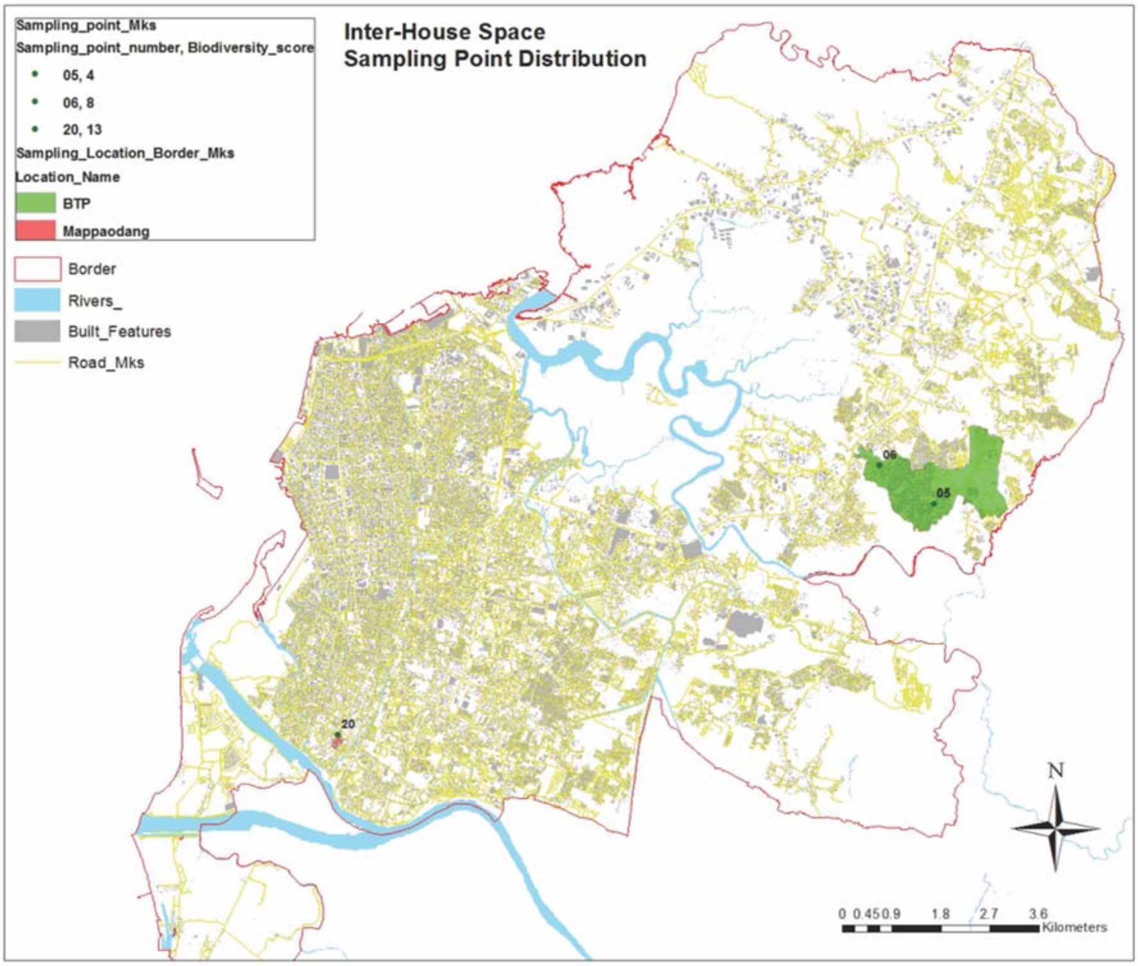

Figure 7.23. Distribution of sampling points of inter-house space surveyed

This study chose inter-house spaces which are quite large and still dominated by natural vegetation growth, indicating a significant period of negligence. However, their existence remains fragile because of the threat of development. This situation might not be the same for individual house gardens.

Figure 7.24. Inter-house space in one old residential complex in Makassar

The government is concerned about green spaces available within residential areas. Like spaces for commercial grounds, the standard and regulations issued by the Ministry of Public Works (Minister of Public Works, 2008) mentions what appear to be inter-house space and allow each local authority to regulate these through local acts. The general regulation sets a minimum area for different types of house yard based on the size of house. Unfortunately, again there is no known local application responding to this national prescription.

In the sense of potential, as identified by the detailed space inventory of one district of Makassar, inter-house spaces are very significant in terms of the total green area of the city. Figure 7.24 illustrates the scale of the availability of these spaces and if the government can manage these under appropriate schemes, they could contribute to the total green space in the city. The potential of domestic gardens has been confirmed by other studies (Gaston et al., 2005), and when residential areas are well vegetated, they might constitute corridors for migrating birds, providing food and protection for them against aerial predators (Savard et al., 2000). Other interesting evidence brought forward by Gregory and Baillie (1998) and Mason (2000), in Gaston, et al. (2005) revealed that some species which are known to be declining in farmland and the countryside are found in significant numbers in urban domestic gardens. At this point, the private spaces around houses in cities could act as compensating ecological spots for migrating or predator-escaping species given the right conditions of support.

The fact that private spaces have limited access supports them being possible wildlife refuges as less access means less disturbance by humans, although most back gardens will have at least some human use.

7.1.11. Roads

Figure 7.25 shows the location of all types of roads surveyed: main (primary) road, secondary road and tertiary roads.

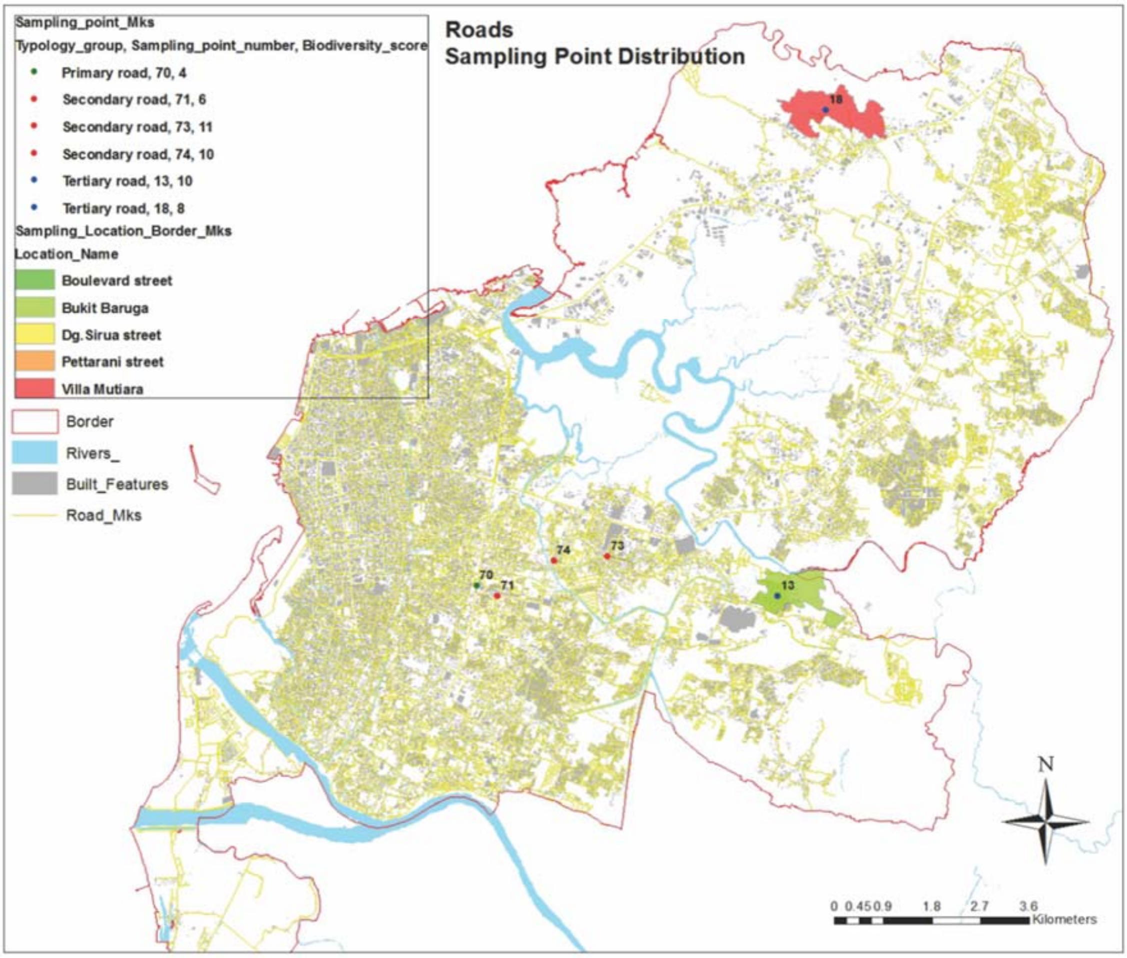

Figure 7.25. Distribution of sampling points of roads surveyed in Makassar

7.1.11.1. Primary road

Table 7.11. Biodiversity score of primary road sampling point

Location Name	Sampling point No.	Vegetation Structures Scores								Number of Vascular Plants	Bio-diversity score
		High trees	Low trees	Bushes	High grasses and forbs	Low grasses and forbs	Ground flora	Aquatic	Built		
Pettarani street	70	6	1	1	1	2	1	0	10	10	4
Total		6	1	1	1	2	1	0	10	10	**4**
Average		6	1	1	1	2	1	0	10	10	**4.00**

The sampled primary road (Pettarani St) according to a study (Adhinugraha, 2010) has been acknowledged as the road with the best vegetation coverage in its median strip compared to other main and primary roads. Although the roadside is not as well vegetated as the median, the existence of well-preserved median trees forms a long green corridor along this road. However, the width of the median is quite narrow as it has undergone constriction from road expansion to cope with traffic development in Makassar. Although according to Adhinugraha's study, the number of vegetation structure types (trees, shrubs and ground cover) in this road corridor is higher than for other roads, the biodiversity score is very low due to the fact the types of plants are not varied and the extent of the built structure (road, pavement) that dominates the location.

Figure 7.26. Pettarani Street, the surveyed main road of Makassar

7.1.11.2. Secondary road

Table 7.12. Biodiversity score of secondary road sampling points

Location Name	Sampling point No.	Vegetation Structures Scores								Number of Vascular Plants	Bio-diversity score
		High trees	Low trees	Bushes	High grasses and forbs	Low grasses and forbs	Ground flora	Aquatic	Built		
Boulevard street	71	1	5	4	1	6	1	0	10	24	6
Dg.Sirua_street	73	6	5	5	5	3	3	0	8	37	11
Dg.Sirua_street	74	4	6	5	4	5	5	1	10	39	10
Total		11	16	14	10	14	9	1	28	100	**27**
Average		3.67	5.33	4.67	3.33	4.67	3.00	0.33	9.33	33.33	**9.00**

Three sampling points in two locations representing secondary roads were surveyed. As for primary roads, hard infrastructure dominated the area, yet the variation of vascular plants is higher than for the main/primary road. Vegetation also tends to be denser with more shrubs and lower vegetation.

Figure 7.27. Panoramic view of three locations of secondary roads in Makassar

7.1.11.3. Tertiary road

Table 7.13. Biodiversity score of tertiary road sampling points

Location Name	Sampling point No.	Vegetation Structures Scores								Number of Vascular Plants	Bio-diversity score
		High trees	Low trees	Bushes	High grasses and forbs	Low grasses and forbs	Ground flora	Aquatic	Built		
Bukit Baruga	13	8	5	3	0	2	2	0	9	48	10
Villa Mutiara	18	6	4	3	0	4	1	0	9	34	8
Total		14	9	6	0	6	3	0	18	82	**18**
Average		7.00	4.50	3.00	0.00	3.00	1.50	0.00	9.00	41.00	**9.00**

The study took two residential areas for assessing the biodiversity of tertiary roads. Like most housing roads, the corridors are generally formed by vegetation growing within the private properties. The tertiary road tends to have little or no roadside space for growing vegetation, thus is reliant on in-property greenery. This could be an issue to address if this space type is counted as part of the city green space, as an owner could easily decide to get rid the vegetation in their house yard. Ideally there should be a way to keep the corridor green without depending on private spaces.

Despite the same average biodiversity score for secondary and tertiary roads, it appears that among all types of road, the lower the class of the road, the better the biodiversity. There are factors that could explain this. Smaller roads are closer to or within residential areas, therefore there is a contribution to the overall biodiversity score from vegetation within properties. This can be seen from the average number of recorded vascular plants. Apart from that, built structures around smaller roads are not as intense as for primary roads. It is still common to see earth surface pedestrian ways in housing roads across Makassar, while the main road is required to have a paved roadside for pedestrians, as well as reinforced kerbs and edges.

Figure 7.28. Three panoramic views of housing roads (tertiary road) at two residential locations in Makassar

7.1.12. River corridors

As mentioned earlier river corridors were not surveyed during the fieldwork. River corridor biodiversity is assumed to be represented by other typologies, specifically urban farms and fishponds that lie alongside the main rivers in Makassar. These appear to already form corridors from a series of patches. Further explanation of this is given in the next chapter.

Nevertheless, in other spots apart from farms and fishponds, it should be noted that natural vegetation, mainly Nypa palm, dominates these corridors. Consequently, they are appreciated and have been targeted for optimization of river biota ecosystem development as well as for a conservation area, mainly leading to the creation of green space alongside river corridors. For this purpose it is important to protect the area with local regulation to prevent further destruction and encroachment by people living near the rivers (Anonymous, 2012).

Figure 7.29. Mangroves as dominant vegetation in estuaries (left) and rivers (right) of the Tallo River, Makassar
(Source: Sebastian (2010))

7.2. The problem of corridors

The application of this RBA to spaces in Makassar did not differentiate between patches and corridors. For most corridors, the circle type sampling point seemed not really efficient as in practice often significant areas of the circle reach far outside the corridor boundary, especially on narrow corridors such as roads and streams and canals. Reducing the circle size would be inconsistent with the adapted approach of the method. This might have influenced the corridor scores but does not seem to have created discrepancies between the obtained score and the observable facts. The fact that most narrow corridors in Makassar (roads and stream/canal) scored low is in line with their physical appearances such as lack of plant diversity and significant presence of built and hard materials.

Nevertheless, having performed the biodiversity assessment during the fieldwork, it seems there is a need to use a different method and approach for assessing corridors, probably at least in setting up the sampling point. The characteristics of corridors are different from patches, which were not part of the original method of Tzoulas and James (2010) as the UK study, which this method was developed from, had all surveyed locations in the form of patches or wide patch-like corridors.

7.3. Summary

This chapter presents the result of biodiversity assessment using the adapted RBA in spaces which represent all typologies. The results are in form of a biodiversity score for each sampling point of the associated typology. Along with the score, a general description of the physical condition of each sampled typology was collected together with panoramic photographs. Some typologies that according to the priority analysis before the fieldwork are medium or even low in priority, such as un-built space and empty space, appeared to have higher scores compared to other typologies. On the other hand, primary roads, which were highlighted and assumed to have significant potential scored relatively low in the assessment. How these scores can be used to further explore priorities will be presented in the next chapter.

Chapter 8

Assessing Quality of Spaces

This chapter consists of three main parts concerning assessment of the quality of spaces. The first describes how the biodiversity score was obtained, the relationship of these scores with other aspects and how the scores were classified into three different levels of 'ecological' quality. The second part discusses urban birds as a factor to consider in selecting spaces for making into a green or ecological network. The third part considers size and ownership status of the green spaces.

8.1. Biodiversity Score

How the various spaces scored as a result of using the RBA method has been set out in Chapter 7, with scores for each typology group and how these were distributed among the different sampling locations. It is now important for the network planning to compare the scores of all typology groups and classify them, in order to identify spaces of similar quality in terms of biodiversity.

The original method of RBA as developed by Tzoulas and James (2010) did not suggest whether a certain range of biodiversity scores is high, medium or low in terms of the ecological quality of any category. The simple rule is the higher the biodiversity the better the site, presumably in terms of the land coverage of various vegetation structures or the diversity of vascular plants, or a combination of both. Also, the UK did not suggest a minimum or maximum score, as the score is dependent on the diversity of vascular plants. Ranking the outcomes was not part of the UK study, which was to test and validate the method.

However, this study needs to have spaces divided into different categories of high, medium and low biodiversity levels, in order to determine the potential for spaces to be included in a network. At this stage, all spaces of similar biodiversity condition are assumed to be within the same range of scores, once these are established. Therefore the categorization is essential to be able to link up spaces within same scoring range. The ideal condition is to connect all high scoring spaces without disregarding the potential of medium and even low scoring spaces for inclusion.

Table 8.1 shows the biodiversity scoring of all typology groups and has been sorted by groups of higher scores.

8.1.1. The relationship between number of sampling points and score

According to the original RBA method, the different number of sampling points should be an indication of the different sizes of sampling areas i.e. the larger the size, the greater the number of sampling points required. As a consequence, Tzoulas & James (2010) did not use the average value to compare the biodiversity of their study sites. According to their UK study, larger sites deserve a higher score because of the accumulation of scores of more sampling points, and it is acceptable for large sites to have more sampling points because it is presumed they have greater diversity than smaller sites.

Table 8.1. Biodiversity score of each typology, space and corridor

No	Typology Group	No. of sampling points	Biodiversity Score	
			Total	Average
1	Urban farm	11	175	15.91
2	Wetland	9	132	14.67
3	Institutional space	14	203	14.50
4	Empty Field	11	158	14.36
5	Un-built space	5	67	13.40
6	Public open/green space	10	131	13.10
7	Fish pond	3	38	12.67
8	Stream/canal	1	11	11.00
9	Public field	1	10	10.00
10	Secondary road	3	27	9.00
11	Tertiary road	2	18	9.00
12	Inter house space	3	25	8.33
13	Primary road	1	4	4.00
	Total	74	999	11.53

However as the main purpose of the biodiversity assessment was not to assess the biodiversity state of Makassar as a region but to get an understanding of the biodiversity of each prescribed typology, the determination of sampling locations was deliberately made according to their priority levels as determined in Table 5.5. This means the different number of sampling points could be an indication of a number of factors. Firstly, the typology with more sampling points has a high priority, based on the priority analysis presented in Section 5.3.2. Secondly, the number of spaces belonging to a certain typology in the study location means this type was more numerous than others. Thirdly, the variations observed in the aerial photographs led to the decision to use more sampling points in some locations, which was then confirmed on site. Lastly, the typologies with smaller numbers of sampling points appeared homogenous in their appearance from both aerial photographs and site visits throughout the Makassar region (such as fish ponds), hence the surveyed sites were assumed to be representative of others of the type.

Therefore, the average value of the scores for each typology is used for their comparison as this study did not survey all sites of each typology available in Makassar, meaning the use of a sum value would not be appropriate. Nevertheless, the principles applied by the original RBA method in terms of sampling techniques were also applied in the Makassar study (see Chapter 6). Table 8.2 shows the locations in Makassar of all sampling points surveyed.

A 60m radius sampling point covers an area of 11,309.7m^2, equal to 1.13 hectares ($\pi.r^2$). Hence the percentage of sampled area coverage could be calculated as presented in Table 8.2. It shows that in some locations, the coverage of sampling points was much larger than the suggested 10% of the particular sampling location. In one location, a private space in Adyaksa, the prescribed sampling area exceeded the total area of the location. For such a location in practice the survey simply covered all the area to the border, although vascular plant identification was still performed by following the transect path up to the border and stopping there even if the distance was less than 120m. Therefore, even if the prescribed sampling size was a 60m radius, for this location the application could be less because of the small size of the surveyed area. On the other hand, some other locations have sampled areas below the suggested 10%.

These two different conditions happened because the determination of sampling locations for this study put emphasis on capturing the variety of the land mosaic pattern to be representative of the vegetation coverage. Hence there are many spaces where, despite the total size being small and where only one sampling point should be enough as the coverage would be far more than 10%, this study still selected more sampling spots, because observation of the aerial photographs showed a considerable variability in coverage patterns. Similarly, some locations seemed too large for the one or two sampling points used, but because of the homogenous land use and vegetation coverage, a small number of sampling points were considered sufficient to cover the variability in such locations. This can be seen for all cultured fish ponds and most paddy fields.

Table 8.2. Sampling location with the types of typology present at that site

Location No.	Name of Location	Type of Location	Area (ha)	Number of Sampling points	Percentage of sampled area *	Typology group present within the location
01	Bumi Tamalanrea Permai (BTP) and its surrounding	Residential complex	250.57	10	4.51	EF, IS, US, UF
02	Bukit Baruga	Residential complex	82.98	5	7.40	OS, TR, UF
03	Villa Mutiara	Residential complex	107.52	4	4.58	TR, US
04	Mappaodang	Part of private property	3.34	2	67.72	IS, US
05	University of Hasanuddin	Campus ground	165.50	7	4.78	IS
06	Gedung Juang 45	Meeting hall	4.88	2	46.35	EF, IS
07	Governor's Office	Government facility	17.21	3	19.71	IS
08	Al Markaz Al Islami	Islamic centre	3.56	2	63.54	IS
09	A space at Urip Sumoharjo (behind finance bld)	Urban farm	7.71	4	58.68	OS, UF, WL
10	Urban Farm at Borong	Paddy field	38.82	1	2.91	UF
11	Baddoka	Urban farm	85.09	3	3.99	UF
12	Karebosi	Public open space and sport field	3.92	1	28.85	PF
13	Dg. Tata	ex-horse race circuit	7.99	2	28.31	EF
14	Baddoka Golf Course	Golf course	50.13	3	6.77	OS
15	Panaikang cemetery	Public cemetery	10.64	2	21.26	OS
16	Taman Macan	City park	1.50	1	75.40	OS
17	Teuku Umar fishing lake	Shallow lake/pond	7.26	2	31.16	WL
18	Kera-kera	Cultured fish pond	4.82	1	23.46	FP
19	Metro Tanjung Bunga	Cultured fish pond	5.46	1	20.71	FP
20	Sutarmi highway	Cultured fish pond	28.40	1	3.98	FP
21	Wetland at Borong	Marshland	6.31	2	35.85	WL
22	Minasa Upa	Marshland	14.47	2	15.63	WL
23	Panakkukang	Swamp	2.57	2	88.01	WL
24	Teuku Umar	Part of private property	1.86	1	60.80	EF
25	Adyaksa	Part of private property	1.71	2	132.28	EF
26	Antang	Urban farm	29.40	3	11.54	UF
27	Pettarani street	Main/primary road	corridor	1	n/a	PR
28	Boulevard street	Secondary road	corridor	1	n/a	SR
29	Dg. Sirua street	Secondary road	corridor	3	n/a	SR, SC

Notes: ** Percentage of sampled area was calculated based on prescribed coverage area upon application of all sampling points, despite the fact in practice the application did not fully meet the prescribed size due to the nature of surveyed locations*

IH = Inter-house space | **CS** = Commercial space | **US** = Un-built space
EF = Empty field | **IS** = Institutional space | **PF** = Public field
OS = Public open/green space | **WL** = Wetland | **FP** = Fish pond
UF = Urban farm | **PR** = Primary road corridor | **SR** = Secondary road corridor
TR = Tertiary road corridor | **RC** = River corridor | **SC** = Stream/canal corridor
IP = In-property corridor

The shape of the location also determined the use of more sampling points despite the size being small enough for only one sampling point. A patch in the form of a long narrow rectangle, for example, might be less than 2 hectares in size. Although 1 sampling point of 1.13 hectare coverage would be more than enough, because the length is far more than 60m (the prescribed sampling radius) and the vegetation coverage variation at the two ends was significantly different, at least 2 sampling points were required. This was done, even though in practice the total coverage of the sampling point in such a location would not be exactly 3.5 hectare because the prescribed circle would be limited by the site border. Locations with spread patches could also require more sampling points, even if their total size is small. The physical condition of a site such as its topography, the existence of watery areas and certain on-site physical barriers, could also lead to more sampling points for a small site in this study.

The following images show illustrations of such locations and how the sampling coverage could appear much larger than the actual practice in the field.

Figure 8.1. Some locations where the sampling point coverage far exceeds the required 10%

Picture a is part of an area of private property. One sampling circle in the middle would cover almost 50% of the area, yet the variations in the north and south parts would not be included, therefore two sampling points were used. The actual sampling area in practice did not equal the area of both circles, because significant parts of the circle (coloured orange) were not surveyed as these are outside the location boundary. Picture b shows two sampling points as a result of dispersed patches crossed by a major road. It was impossible to set the starting point in the middle of both patches because of this primary road. Picture c is an example of a location where more sampling points were used due to a physical barrier on the site, in this case a large area of water.

8.1.2. Scoring classification

Biodiversity is the main consideration in assessing the potential of spaces in each typology. However, as the typology was developed considering a number of factors as explained in Chapter 5, the final classification needs to correspond to those factors in such a way that the biodiversity scoring classification is, as much as possible, in line with the field observations and the pre-survey assumptions. Therefore, after obtaining the scores for all typologies it was decided to classify the typologies into the three groups of ‘high’, ‘medium’ and ‘low’. In order to do this, different approaches were taken and compared before the final categorization was made.

Table 8.3 presents the comparison of three different approaches as a way to see whether previous assumptions based on aspects such as size, ownership status, accessibility, constraints, and vegetation and biodiversity state were in line with the fieldwork result. The fieldwork result gives scores of biodiversity as a measured variable. Other aspects such as vegetation structure and vascular plant diversity were also observed when undertaking the RBA and will be discussed later. Other factors which were assumed in the pre-survey priority analysis were also observed during the fieldwork and will be considered and analysed qualitatively. Together, these will lead to an analysis of ecological network feasibility in the study location.

The B column of Table 8.3 is one approach by taking the biodiversity score as the indicator. It is a classification made by allocating an equal range of scores from the lowest to the highest. As the lowest score is 4 and the highest score is 16 (rounding of 15.91), this gives a range of 12. The number of required groups is three, hence each group has a range of 4. Therefore a score of 4.0 – 8.0 is low, 8.1 - 12.0 is medium and 12.1 – 16.0 is high. Using this classification approach produces an unbalanced result and deviates significantly from the priority analysis. Furthermore according to fieldwork observation, placing some spaces at medium level in this approach would be inappropriate.

Table 8.3. Categorization of biodiversity scores under three different approaches

No.	Typology Group	Categorization Approach									
		Pre-survey assumption (based on secondary information and local knowledge)			**Bio-diversity average score**	**Approaches Based on Fieldwork result**					
		A. Priority analysis				***B. Equal distribution***			***C. Standard Deviation***		
		High	Medium	Low		High	Medium	Low	High	Medium	Low
1	Urban farm	✓			**15.91**	✓			✓		
2	Wetland	✓			**14.67**	✓			✓		
3	Institutional space	✓			**14.50**	✓			✓		
4	Empty Field		✓		**14.36**	✓			✓		
5	Un-built space			✓	**13.40**	✓			✓		
6	Public open/green space	✓			**13.10**	✓				✓	
7	Fish pond		✓		**12.67**	✓				✓	
8	Stream/canal		✓		**11.00**		✓			✓	
9	Public field		✓		**10.00**		✓			✓	
10	Secondary road			✓	**9.00**		✓				✓
11	Tertiary road			✓	**9.00**		✓				✓
12	Inter house space			✓	**8.33**		✓				✓
13	Primary road	✓			**4.00**			✓			✓
14	Commercial space *			✓							
15	River corridor *	✓									
16	In-property corridor *			✓							

Note: * These typology groups were not surveyed; the biodiversity level was made following pre-survey assumptions, on-site observation and similarities with other typology group/s.

The C column is also a biodiversity-based classification approach. The categorization is based on standard deviation. The calculation and statistical analysis is presented in Appendix 3. Under this categorization more balanced groups are created that give a good match with the results of the field observations and pre-survey assumptions, despite some differences as explained above. Therefore the classification based on the biodiversity score is made following this process and the spaces considered ‘high’ in biodiversity score will be taken as the priority for further mapping and analysis. Nevertheless the ‘medium’ and ‘low’ spaces will also be addressed, regarding the principle that every spot with a natural content has potential (Carmona et al., 2004).

Having set a level category for the biodiversity score for each typology group, it is then necessary to consider all identified spaces of a particular typology to determine their biodiversity levels even though they were not surveyed, and aerial photograph observation does not support this biodiversity level. This is because they are assumed to have the potential to achieve this biodiversity level, because of their similar basic land use characteristics relative to others in the same typology classification.

8.1.3. Explanation of assumptions

The field work confirmed several assumptions made in the priority analysis were not true attributes of the typologies in question. Primary roads, for example, were given a high priority in the analysis following the assumption that they meet the technical specification for establishing wide green corridors, but turned out to be different. It was observed during the fieldwork that this would not be feasible, or that such roads would have to be optimised to realise the potential, as they scored low in the biodiversity assessment. Figure 8.2 shows why a primary road in Makassar is not in the expected condition, yet still has potential for improvement. The possibility for improvement may not apply to highways running across the city but could be used for highways leading out of the city. These roads have wider corridors and hence more potential for being part of a viable green network. In terms of the environmental benefits of greening roads, studies and modelling in Europe have shown a large difference in air temperature between sparsely tree-covered and densely tree-covered streets, with lower temperatures in the surroundings of the latter (Ridder, 2004).

Un-built space was given a lower priority due to its status, which is very fragile because of development and conversion in the near future. However, it appeared in the fieldwork that such spaces have high potential in terms of land coverage and vegetation structure, and hence they scored high in biodiversity.

River and commercial spaces were also considered in the pre-survey analysis. Commercial places were thought to have low potential because of issues such as ownership, accessibility and possibility for conversion. Fieldwork confirmed this space as difficult to access, even just to gain a permit for the survey, even though this type of space has been included as a type of urban green open space by the Ministry of Public Works (2008). Because this type of space could not be accessed for assessment it is not included in these results.

Figure 8.2. Tol Reformasi, a primary highway in Makassar (a and b) has the potential to be made greener and possibly carry ecological value as in picture c (Cross Florida Greenway) Source: a: Google Earth, 2010; b: Sizemore (2009)

River corridors are an important separate type because they are a linear feature and therefore a natural inclusion in any network. However, in this study they were not surveyed as a separate type for a number of reasons. First of all, the river corridors in the city have several land uses, putting these in different typology groups, including fish ponds, urban farms and wetlands. Another part of the river corridor is not represented by any typology, as the bulk is covered with native Nypa palms, which are fundamentally the natural appearance of local river corridors. Knowing that space along the main river in Makassar has also been designated for cultural uses such as fish ponds and urban farms as well as wetlands, the biodiversity of the river corridors should relate to that of these typology groups. Urban farms and wetlands are high in biodiversity, whereas the fish pond is medium. Moreover, observation has shown that the parts of the Makassar river corridors covered with native palms are high in biodiversity because they are still natural and densely vegetated. The fish ponds scored medium because of their vegetation structure, given they are a monoculture and there is a lack of dense vegetation. Assuming that other parts of the river corridors would score as well as the fish ponds and urban farms (medium or high) means the state of the river corridors is close to ‘high’. Combining this with the good biodiversity of the vegetation structure of the natural remnants of river the corridors, leads to the overall assumption that river corridors can be assumed to score ‘high’ in biodiversity.

One reason for not surveying the native palm area alongside rivers is safety. It was difficult and risky to go to the exact locations of the natural remnants of river corridors in Makassar. The areas which are mainly a mass of Nypa palm may impose danger for the surveyors due to their morphology, not to mention the threat from unfriendly animals in the river such as snakes and crocodiles. Nevertheless, river corridors can be placed in the category of ‘high’ biodiversity with confidence. In addition to the reasons mentioned, the existence of natural vegetation in scattered parts of the corridor of Makassar’s main river has been acknowledged by the local government. The area of Lakkang, which is part of river corridor in the district of Tallo, has been officially proclaimed a conservation area with natural and cultural qualities. This acknowledgement is included in the official government spatial planning document for 2016 (Makassar City Council, 2006).

Figure 8.3. Area of Lakkang with conservation spots, a strategic area for preservation acknowledged by the city council (Source: Anonymous (2010))

Rivers, therefore, have high potential as ecological corridors if the spaces along their sides are well preserved and undisturbed. The pre-survey accordingly classified rivers into the high priority group.

The best application of a corridor along rivers would be as described by Forman (1995), “a strip of vegetation that encloses a channel with flowing water”. This would be more optimized when there is no or very little activity present (Davenport, Davenport, Huijser, & Clevenger, 2006), and when the channel is well vegetated (Tabacchi et al., 1998). However this kind of ideal corridor does not exist and would probably be very hard to establish alongside the rivers that run through Makassar city. This is a serious concern as Makassar has not yet turned into a big industrialized city whose rivers have been almost totally altered from their natural state (Baschak & Brown, 1995), thus ideally there should still be preservation of space for green corridors along the city's rivers, particularly as the dominant spaces around river banks are agricultural fields. With encouragement such a move should have a strong outcome as the urban farm typology is a space with a high biodiversity score.

Another problem of the river corridors in Makassar is similar to a common problem of urban areas as described by Cook (1991), where remnant patches and corridors have often been developed into 'cultural' features. These features despite being suitable for human requirements are no longer suitable for the native species which originally inhabited the space but which, because of development, can no longer find supporting characteristics in the space.

Figure 8.4. Cultivated fields along main rivers in Makassar, agricultural fields (left) and fish ponds (right). (Source: Google Earth 2011)

Taking the standard deviation approach as the way to classify the biodiversity scores, and the assumptions made for typologies whose scores are based on those of other typologies and field observations, the distribution of spaces in Makassar based on biodiversity level can be seen in Figure 8.5.

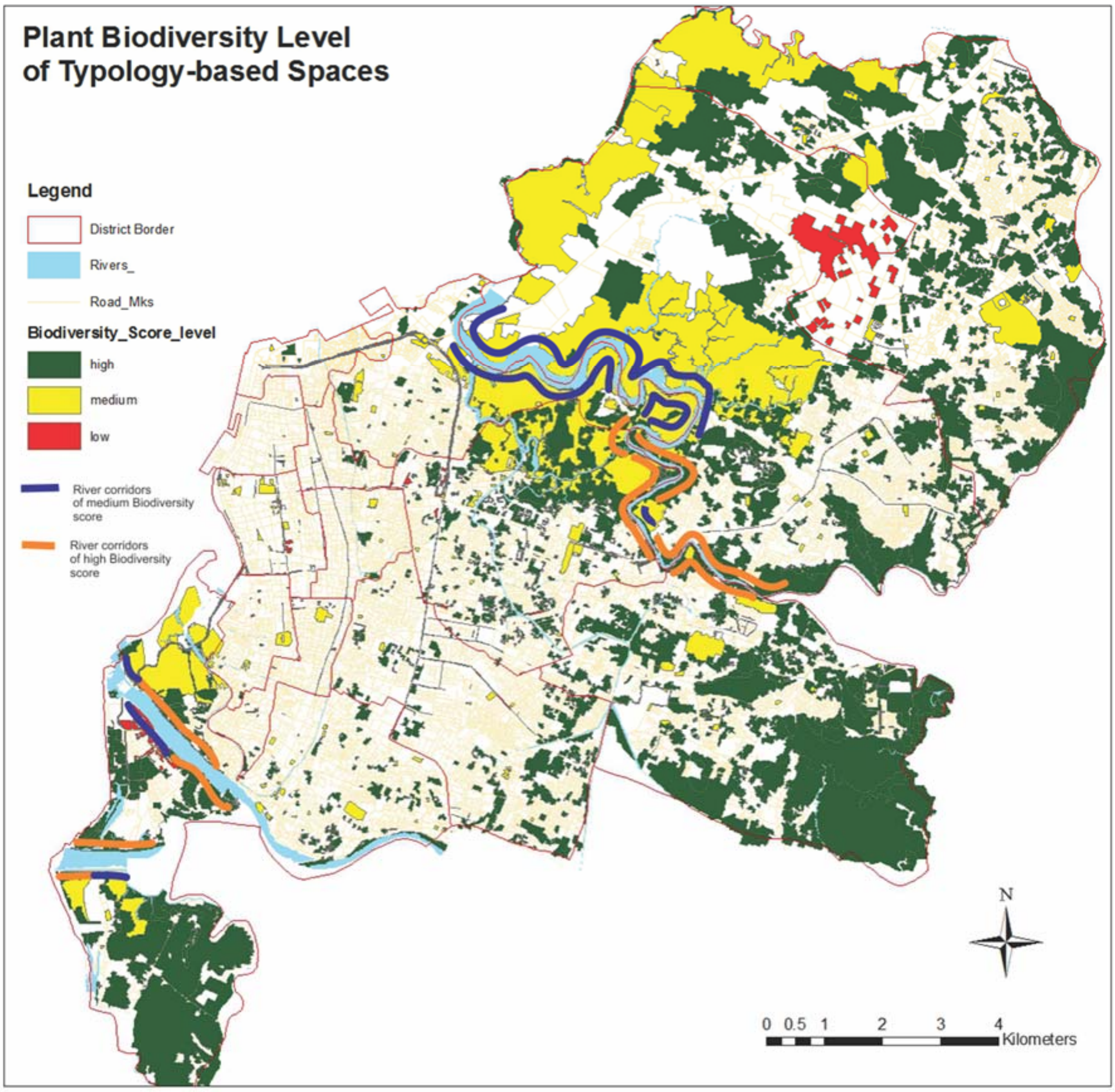

Figure 8.5. Distribution of plant biodiversity score level for spaces in Makassar

The priority analysis took many aspects into consideration, whereas the main focus of the fieldwork was on biodiversity. This is one factor that leads to the further recommendation of a need to look at all spaces, even if they are low in biodiversity, as they may have potential in other aspects, such as their large numbers, possible functions, and accessibility to users. Regarding accessibility, whether a space is considered favourable or not depends on the main function and use of the particular space. The priority analysis considered spaces which have possible public use in the future due to their potential amenity as ones that need good accessibility. On the other hand, spaces which are considered to be a preserved habitat or ecological spot would have a better value if their accessibility is poor. However, apart from few remnant patches along corridors, Makassar has few such spaces.

It is possible to be confident about the potential of open spaces in the city as most score high for biodiversity with only small proportion of spaces scoring low, as seen in Figure 8.6.

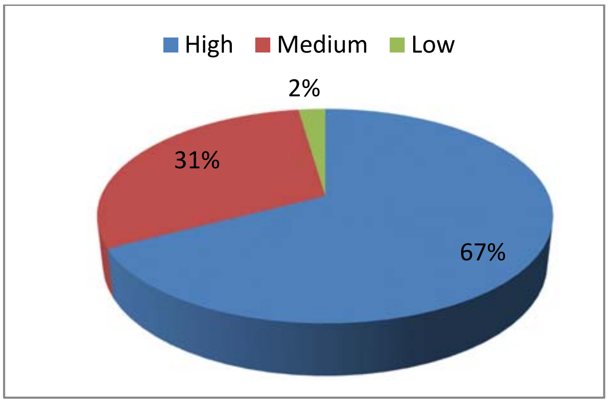

Figure 8.6. Proportion of biodiversity level for spaces in Makassar

8.1.4. Biodiversity as an important consideration for prioritizing spaces for a network

This study has used biodiversity as the main factor for assessing the potential feasibility of existing green areas to be part of an ecological network. Although the assessment method used here only covers plant biodiversity, it can still be an indicator of viable spots with possible habitat with ecological value. Furthermore, having knowledge about the vegetation state and variability of the study location could lead to further possible alternatives. By applying more filters or criteria, which form essence of the following part, the analysis might reveal information that could lead to knowing whether it is possible to establish an ecological or a green network.

This study made an early assumption that it might be possible to establishment what could be described as an 'ecological green network'. This implies having an ecological network where possible, but linking this to a green network in places where some qualities are not met, or even just to a park network or something with a smaller scope. The feasibility of establishing an ecological network depends on whether the observed patches and corridors could serve as refuge sites. Furthermore, this will require a viable system which allows ecological processes favourable to resident species to persist.

The RBA method unfortunately does not provide a quantitative procedure for assessing the viability of the surveyed patches as ecological spots in terms of quality of ecological dynamics and system. This method only provides scores that reflect the biodiversity state, and then mainly regarding two factors: vegetation structure and vascular plants diversity. This, however, should represent the general state of biodiversity as vegetation structure is the main determinant of habitat complexity, and numerous studies indicate that the composition and complexity of habitats could be good indicator of overall biodiversity (Tzoulas & James, 2010). Moreover, other literature suggests that the structural composition of vegetation can be used in urban habitats as a substitute for their biodiversity assessment (Cornelis & Hermy, 2004). Additionally, Cook (2002) stressed the importance of having knowledge of the vegetation structure, because vegetative coverage is one factor that contributes to ecological health and can be indicative of wildlife habitat, as well as being a vegetation attribute that indicates ecological value.

Vegetation structure as observed within the RBA could also be analysed to get a description of the types of dominating vegetation in certain spaces typologies, and whether it is possible to link up spaces with similar vegetation types, since these can carry special function, for example as a habitat for certain trees. Dominance of vegetation structure can also be used to denote the possible utilization of certain spaces when certain ecosystem services or recreational benefits become the target.

Furthermore, the field activity conducted along with the biodiversity assessment also included observation of other factors which were looked at in the pre-survey analysis. The fieldwork made it possible to confirm whether all assumptions made matched the actual condition, whether they were slightly different, or even if they were contradictory. This confirmation is necessary to decide how the scores of biodiversity can be best classified. The biodiversity state of spaces plus other additional consideration in the city will determine which type of network is more applicable to Makassar.

8.2. Assessing spaces with species consideration: Urban birds

Analysis on connectivity between spaces in urban areas could also be made by considering the accommodation of a particular urban animal species. Any assessment made would be more focussed when a specific target or indicator species is established. A target species in this context refers to a component of nature which needs attention due to its importance in the landscape and sensitivity to its change (Hepcan et al., 2009) and to species which are sensitive to fragmentation (J. Linehan, Gross, & Finn, 1995). For urban biodiversity, identifying desirable species is important especially in the context of the interaction of people and possible wildlife in an urban setting (Savard et al., 2000). Acknowledgement of a particular species of interest could help in assessing spaces based on its habitat needs, its range, and its representational values in further analysis (J. Linehan et al., 1995).

Birds are commonly found within urban areas, and can therefore form a useful target species. Some urban bird species are sensitive towards urban environmental change in terms of habitat structure and composition (Savard et al., 2000), making them useful for any discussion regarding nature in urban areas.

Modern society is familiar with the term ‘back to nature’ and its suggestion of a natural experience even in highly urbanized areas. The sound of birds is expected to provide a sense of relaxation to help reduce the stress of a hectic urban life. Birds are an urban species which should be targeted for preservation given their value for people in urban areas (Hidayansyah, 2007). In addition, birds have a role as indicators of biodiversity. They can even be taken as direct indicator (Soendjoto & Gunawan, 2003). Diversity of bird species in an area reflects its viable and vigorous wildlife and habitat (Widodo, 2012). The existence of birds in urban areas especially relates to the viability of food webs as almost all webs have birds as a component (Hernowo & Prasetyo, 1989) due to their ability to be present in a variety of habitat types at different altitudes (Widodo, 2012).

For a city like Makassar, urban birds tend to become rarer as the city develops. Some species which were identified by a study in Java such as burung gereja (*Passer montanus*), kutilang (*Pycnonotus aurigaster*), wallet (*Collocalia linchi*), burung madu (*Nectarinia jugularis* and *Anthreptes malaccensis*), and pipit (*Lonchura leucogastroides*) (Ontario, Hernowo, Haryanto, & Ekarelawan, 1990) are known and can be found in Makassar. However, it is becoming more difficult to see them within the urban matrix. Despite a lack of studies of birds in Makassar, it is still worth considering them as a target species, especially considering domesticated birds are popular and bird vendors in traditional markets make a good living in the city. This suggests that people appreciate having birds around them, hence providing an environment which promotes bird life would presumably be acceptable to those living in Makassar. Hernowo and Prasetyo (1989) mentioned the importance of birds and their benefits for the economy, recreation and education. This also applies in Makassar, especially for a bird species which could give economic benefits to people such as the wallet (*Collocalia linchi*) for its high value nest (Ahira, 2009), and 'kutilang' and 'tekukur' for their attractive and beautiful voices and colours, which make them high value market bird species.

Figure 8.7. Views of two popular pet markets in Makassar, showing birds are a popular species, and indicating people's appreciation of them.
Source: Tahir (2012); Pustaka Sekolah (2013)

Not only are domesticated caged birds valued, but people in the city also encourage the existence of free birds in their neighbourhood by providing a 'home' for them as seen in Figure 8.8.

Figure 8.8. Bird house deliberately set in road median tree

8.2.1. The habitat preference of birds

Research by Ontario, et al. (1990) in Jakarta showed that residential areas with higher vegetation cover had a high diversity of bird species. However, locations which are well vegetated in this way are not often found in Makassar. Green open space may be the last bastion for populations of urban birds. One optimal form of green space that accommodates birds well is urban forests, as they act as a site for nature conservation. The structure of multi-storey vegetation will provide growing space for different types of plants (other than trees), such as shrubs, bushes, and epiphytes, creating a high diversity of flora. These conditions will create a habitat for many species of wildlife, especially birds, by providing food, cover (shelter), playgrounds, and breeding room. Cook (2002) stressed the importance of having diversity in the structures of plants to provide greater diversity of habitat types, as this helps to increase the diversity of other species and their survival in a tough urban environment. Additionally, areas with a high density of vegetation cover, such as river corridors and well vegetated green spaces, are a good refuge for birds. Apart from these, areas which can be well preserved and protected from disturbance from human activities can also serve as a bird sanctuary (Widodo, 2012).

The ability of certain areas to harbour urban birds depends on the size of the area, vegetation structure and composition, ecosystem type, and the shape of the boundary, as well as the potential security of the urban birds. An area with a more diverse ecosystem type is more feasible for accommodating the needs of urban birds due to it having more complete components within. The diverse ecosystem constitutes diverse levels and structures of vegetation (Hernowo & Prasetyo, 1989).

According to Ballen (1989) in (Samsoedin, 2012), some types of trees common in Indonesian urban areas are popular with and attractive to birds. Some species of *Ficus genera* produce edible fruit for birds, some trees produce nectar, and certain trees are needed for nesting or nest materials. The vegetation of green spaces provides food, water, roosting and nesting sites, and therefore becomes the main determinant for a green space to become a habitat for birds (Hernowo & Prasetyo, 1989). Stagoll (2012) added that birds prefer to breed in parks or green spaces with big trees. Other research in urban forests found a positive correlation between the diversity of bird species and number and types of trees (Hadinoto et al., 2012). Small mammals, lizards and birds have a better chance to escape from their predators through shrub layers, while insects, as another species group which also relates to birds, may be more reliant upon ground cover (Cook, 2002).

Another research project in Padang, an Indonesian city in Sumatra Island, suggested urban parks and urban green corridors form two important features in urban areas because significant numbers and types of urban birds were identified in these (Jarulis, Salsabila, & Bakar, 2005).

Apart from vegetation structures, the size of patches and width of corridors have significance for creating a feasible environment for urban birds. A study by Gavareski (1976) looked at the relationship between park size, vegetation and urban bird populations. He found that although there was no single rule regarding park size and vegetation types for the abundance of urban bird species, the interaction between vegetation and size was significant. The research indicated vegetation might affect the diversity of birds for different park sizes, because large and small parks tend to be significantly different due to the vegetation within each. Location of the park, whether within an urban environment or in a natural area, did not really affect the populations of several urban bird species, but the condition of the vegetation relative to the size of the park did.

The same study also mentioned the significance of location and content of patches and activities within the patches for bird habitats regardless of the size of the parks. This finding is supported by other studies that reported bird populations in modified urban patches were sometimes higher than in comparable natural areas (Gavareski, 1976). Additionally, to support a high diversity of urban birds, adequate vegetation is more important than location of the patches. This was also confirmed by several studies comparing bird communities in different urban habitats (Jarulis et al., 2005; Widodo, 2012).

Based on the considerations above, it can be concluded that understanding the vegetation condition is important for preparing spaces for target urban birds. However there is no information about urban bird target species in Makassar or the specific vegetation preferred by urban birds in this city. In order to decide what kinds and levels of vegetation should be proposed, general assumptions have to be made, based on the arguments above, when analysing patches and corridors to encourage urban birds in this city.

As explained earlier, a biodiversity assessment on vascular plants was performed to see the general biodiversity condition of this main content of a habitat. The assessment includes observation of vegetation structures and Domin value of each structure. Vegetation structure refers to the composition and height variability of trees, shrubs, forbs and grasses in an area (Tzoulas & James, 2010). Domin value refers to a number that quantifies the dominance of each structure upon the overall land coverage of the area by scaling, where the range of 0 – 100 per cent is divided into 10 classes with smaller graduations nearer to the bottom of the scale (Kent & Coker, 1992, p. 45). The procedures and guidelines for evaluating the structure dominance are explained in Chapter 6 of this thesis.

Considering all the research into aspects of urban birds, and based on the vegetation structure and Domin values of different structures, this study can propose patches and corridors which are considered favourable or at least carry potential to be prepared as accommodating spots for urban birds in Makassar (Table 8.4.).

Table 8.4. Table of conditions preferred for creation of bird spots

Conditions required based on studies of Indonesian urban birds		Observable condition in Makassar according to biodiversity assessment approach
A	Various vegetation structures (Hernowo & Prasetyo, 1989)	Existence of all vegetation structures (with or without built structures)
B	Dense vegetation (high vegetation cover) (Ontario et al., 1990)	• More vegetation structures with high Domin value (High average Domin value of all structures excluding the built area) • More existence of vascular plants
C	Areas with big and high trees (Stagoll, 2012); (Hadinoto et al., 2012)	• Existence of trees • High Domin value of high trees.
D	Areas protected or with minimum human activities (Widodo, 2012)	No or minimal built areas

In terms of size, a guideline of the USDA (Bentrup, 2008) proposes certain area sizes considered as suitable spaces for accommodating birds. Grassland birds require an area of over 4.5 hectares while forest birds require an area of over 2 hectares. Urban birds are not specified in this guideline, however as some studies have mentioned the significance of trees and vegetation as favourable spots for birds, it is important to have areas with sufficient space for plants to thrive. An area with robust vegetation would be a place for small animals and the insects on which many birds feed. Nevertheless, even a single tree canopy or a small group of plants could be a resting spot for birds in their movement within an urban area, as birds are a wildlife species which exists in almost any vegetated environment (Hadinoto et al., 2012).

In order to assess the potential for harbouring urban birds, this study analyses the state of the vegetation of sampled locations to see their compatibility with the preferred conditions.

8.2.2. Vegetation structures in study locations

Variation of vegetation in the study locations reflects the biodiversity score obtained through the assessment procedure. The favourable condition for higher biodiversity is achieved when more vegetation structures are present despite the Domin value. Nevertheless, the quality and domination of each vegetation structure may lead to another analysis, such as the need to assess the suitability as a spot for harbouring urban birds. The following table shows the vegetation structures of all sampled locations, representing the different typologies and also reflecting the different land uses.

Table 8.5. Domin value (DV) of various vegetation structures of different typology groups

Typology group	High Trees DV	Low Trees DV	Bushes DV	High Grass DV	Low Grasses DV	Ground Flora DV	Aquatic Flora DV	Built DV	Average Number of Vascular plants	Bio-diversity level	Average number of existing vegetation structures	Average of Total Domin values of all vegetation structures excluding built areas	Average of Total Domin value of all trees
Empty field	4.64	3.82	6.55	3.18	4.73	3.27	1.09	3.55	31.55	High	6.64	27.27	3.78
Fish pond	0.33	0.33	3.00	1.33	1.00	1.00	5.33	0.33	8.67	Medium	6.00	12.33	0.67
Institutional space	6.21	4.57	4.00	2.21	6.50	3.64	0.07	4.86	41.93	High	6.50	27.21	6.64
Inter house space	2.33	2.00	4.00	0.00	3.00	4.00	0.00	9.00	35.67	Low	6.00	15.33	10.79
Primary road	6.00	1.00	1.00	1.00	2.00	1.00	0.00	10.00	10.00	Low	7.00	12.00	8.45
Public field	5.00	0.00	1.00	0.00	9.00	1.00	0.00	4.00	17.00	Medium	5.00	16.00	4.33
Public open/green space	6.70	3.30	2.80	1.00	5.40	1.80	1.00	4.20	29.30	Medium	6.80	22.00	9.00
Secondary road	3.67	5.33	4.67	3.33	4.67	3.00	0.33	9.33	33.33	Low	7.33	25.00	4.60
Stream/canal	6.00	1.00	5.00	6.00	0.00	5.00	1.00	6.00	27.00	Medium	7.00	24.00	11.50
Tertiary road	7.00	4.50	3.00	0.00	3.00	1.50	0.00	9.00	41.00	Low	6.00	19.00	7.00
Un-built space	2.40	2.20	5.00	0.40	7.60	1.20	0.20	2.60	20.80	High	6.40	19.00	5.00
Urban farm	4.18	2.45	3.09	3.09	4.91	3.27	1.64	1.45	26.55	High	7.09	22.64	7.00
Wetland	1.78	2.00	2.44	2.67	3.11	1.78	6.33	2.33	21.89	High	7.33	20.11	10.00
Grand Total	**4.45**	**3.09**	**3.85**	**2.12**	**4.86**	**2.66**	**1.58**	**3.96**	**29.58**	**13.50**	**6.72**	**22.62**	**7.54**

Based on the vegetation structures as presented in Table 8.5, all typologies can be analysed for their compatibility with the required conditions for spots that can accommodate urban birds in Makassar (Table 8.6.). The compatibility matrix is presented in Table 8.7. Any range made to classify the number is based on an equal distribution of the maximum and minimum values of all variables in question.

Table 8.6. Transformation of the required conditions into categorization of Makassar study research parameters

Required condition		Observable Research Parameters																	
		1. Number of Vegetation structures			**2.** All Structures Domin value			**3.** Number of Vascular Plants			**4.** Total Domin value of trees			**5.** Domin value of high trees			**6.** Domin value of built structures		
		Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	High	Med	Low
A	Various vegetation structures	5.00-5.78	5.79-6.57	6.58-7.33	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
B	Dense vegetation (high vegetation cover)	--------	--------	--------	12.00-17.09	17.10-22.19	22.20-27.27	8.67-19.76	19.77-30.86	30.87-41.93	--------	--------	--------	--------	--------	--------	--------	--------	--------
C	Areas with big and high trees	--------	--------	--------	--------	--------	--------	--------	--------	--------	0.67-4.28	4.29-7.90	7.91-11.50	0.33-2.55	2.56-4.78	4.79-7.00	--------	--------	--------
D	Areas protected or with minimum human activities	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	10.00-6.78	6.77-3.55	3.54-0.33

Note: shaded areas are preferred values.

Only the best conditions or high value parameters are taken into account, therefore compatibility with the preferred conditions can be presented as in Table 8.7.

Table 8.7. Matrix of compatibility to meet preference for accommodation of urban birds

Required condition	**Typology Group**												
	Empty field	Fish pond	Institutional space	Inter house space	Primary road	Public field	Public open/ green space	Secondary road	Stream/ canal	Tertiary road	Un-built space	Urban farm	Wetland
A1	✓				✓		✓	✓	✓			✓	✓
B2	✓		✓					✓	✓			✓	
B3	✓		✓	✓				✓		✓			
C4				✓	✓		✓		✓				✓
C5			✓		✓	✓	✓		✓	✓			
D6		✓									✓	✓	✓

Note: shaded areas are preferred typologies with 3 or more fulfilments.

The matrix shows stream/canal corridors as the typology which fulfils most conditions for bird accommodating spots (4 criteria). Other typologies with 3 fulfilments are empty field, institutional space, primary road, public open/green space, secondary road, urban farm and wetland. The fact that some typologies which scored medium and even low in biodiversity such as the corridors (stream and road) possess the qualities for accommodating birds according to this simple analysis, confirms a study performed in another Indonesia city. This showed that green corridors harbour more types and numbers of birds than other types of more common urban green space such as urban parks (Jarulis et al., 2005). Following the approach for analysis of spaces and corridors which were not particularly assessed by the biodiversity scoring work (as explained in Section 8.1.3), river corridors are accordingly also considered favourable for birds, especially as narrower and less natural stream corridors are preferable in this context. Likewise commercial place and in-property corridors, for which the biodiversity score and level are represented by un-built space and tertiary roads, are not preferable for birds following the fact that un-built space and tertiary roads are not preferred in this analysis. Apart from the study of green corridors, two other studies on identifying urban birds have been performed in campus grounds (institutional space) as generally in Indonesia most campus ground have huge vegetated areas with trees as the main vegetation type (Wibowo, (2004), (Sudaryanto, (1997). This indicates that campus grounds should be significant spots for urban birds.

In order to link up spaces when birds are the main consideration, the mapping needs to establish a minimum size of patches and corridors for the preferred groups of typology based on the analysis above. Road corridors are significant as accommodating spots for birds as they tend to have rows of trees. However to optimize their function for bird accommodation, some improvement to the corridors in the city of Makassar is required. Hernowo & Prasetyo (1989) brought forward the importance of having wide green corridors because even a 15m corridor would probably only accommodate two types of birds. In complying with this, the most preferred corridors of road and river/stream would be ones which are 15m or more wide. However, it might be difficult to identify a consistent width of corridor in this study because each is mostly formed of a series of patches alongside either natural or cultural corridors. Although not continuous, the distances between them are sufficiently close to form 'corridors'. In this case the width of these patches might be considered the width of the corridor.

When it comes to patches, previous studies highlight the significance of vegetation for habitats designated for bird accommodation. It is understood that the preference of birds is more strongly influenced by the vegetation condition than the size of the patch. Therefore, despite USDA guidelines setting out the preferable patch size for vegetation of 2.02 hectares, this will not be used here to filter out spaces where the vegetation condition is already good or has the potential to be improved for the accommodation of birds.

Like the analysis on quality of spaces based on biodiversity, the land status becomes an important consideration for whether the spaces or corridors have good feasibility for their inclusion. If such consideration also becomes a filter to obtain only the most feasible spots for accommodation of birds, it is then possible to produce maps of preferred patches and corridors, excluding private and corporate spaces, as seen in Table 8.8 and Figure 8.9.

Table 8.8. Spaces considered preferable for accommodation of birds excluding private and corporate spaces

Typology Group	Sum of Areas (ha)	Percentage of Area (%)
Institutional space	180.86	29.17%
Public open/green space	162.36	26.18%
Wetland	276.85	44.65%
Grand Total	**620.07**	**100.00%**

It seems few spaces are available when land status is considered significant, as by filtering spaces based on ownership only state land, public and institutional spaces are included (Figure 8.9.).

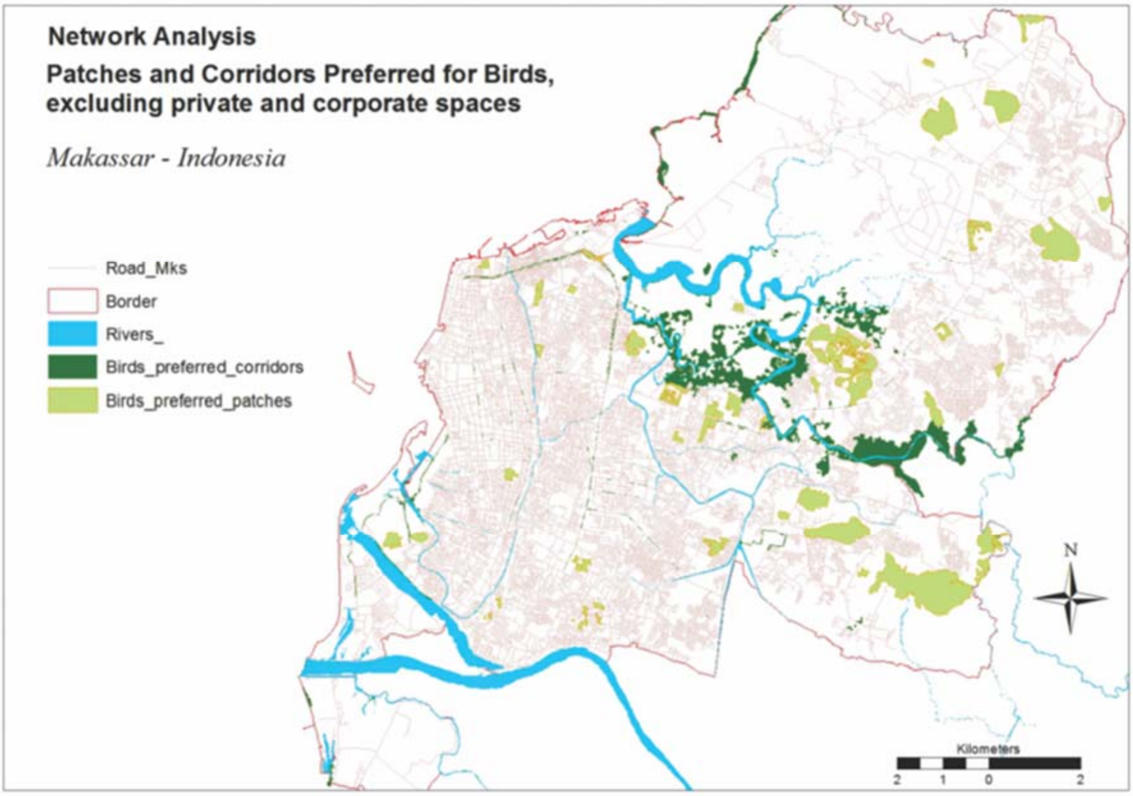

Figure 8.9. Patches and corridors for birds which are most feasible taking land status/ownership as the consideration

On the other hand, if the land status is disregarded and private and corporate spaces included, the number of spaces increases significantly. It is reasonable to do this because for birds vegetation, especially trees, is the most significant component, and there are ways to improve the conditions of trees without interfering too much with the current land use.

Table 8.9. Private and corporate spaces considered best for accommodation of birds in Makassar

Row Labels	Sum of Areas (ha)	Percentage of Area (%)
Empty field	680.96	15.92%
Institutional space	2.86	0.07%
Public open/green space	19.72	0.46%
Urban farm	3348.57	78.29%
Wetland	225.07	5.26%
Grand Total	**4277.18**	**100.00%**

As seen in Table 8.9, the significant private and corporate spaces that are potentially a good environment for birds are urban farms (78.29%), which consist of agriculture in paddy fields and mixed crop fields. These private and corporate spaces are also much larger than the other group of preferred spaces in Table 8.8. The non-private and non-corporate spaces only total 620.07 hectares while the former total 4,277.18 hectares (Table 8.9.), almost seven times more.

Referring to the USDA guide (Idassi, 2012), there are two ways to improve agricultural fields within urban an matrix: windbreak systems and riparian buffers for fields alongside streams and rivers. The application of these two approaches will enrich agricultural fields with plants especially big trees, which are favourable for birds. These types of intervention do not significantly reduce the space for planting of crops, and therefore yields. Therefore, the introduction of these techniques has a better chance of approval, especially when the government provides assistance in their implementation. As a result it seems feasible to include these private and corporate spaces into the potential spaces for birds. Additionally their area is too large to be ignored given that improvements can be made to them, as described.

Consequently, the preferred space network for birds is shown in Figure 8.10.

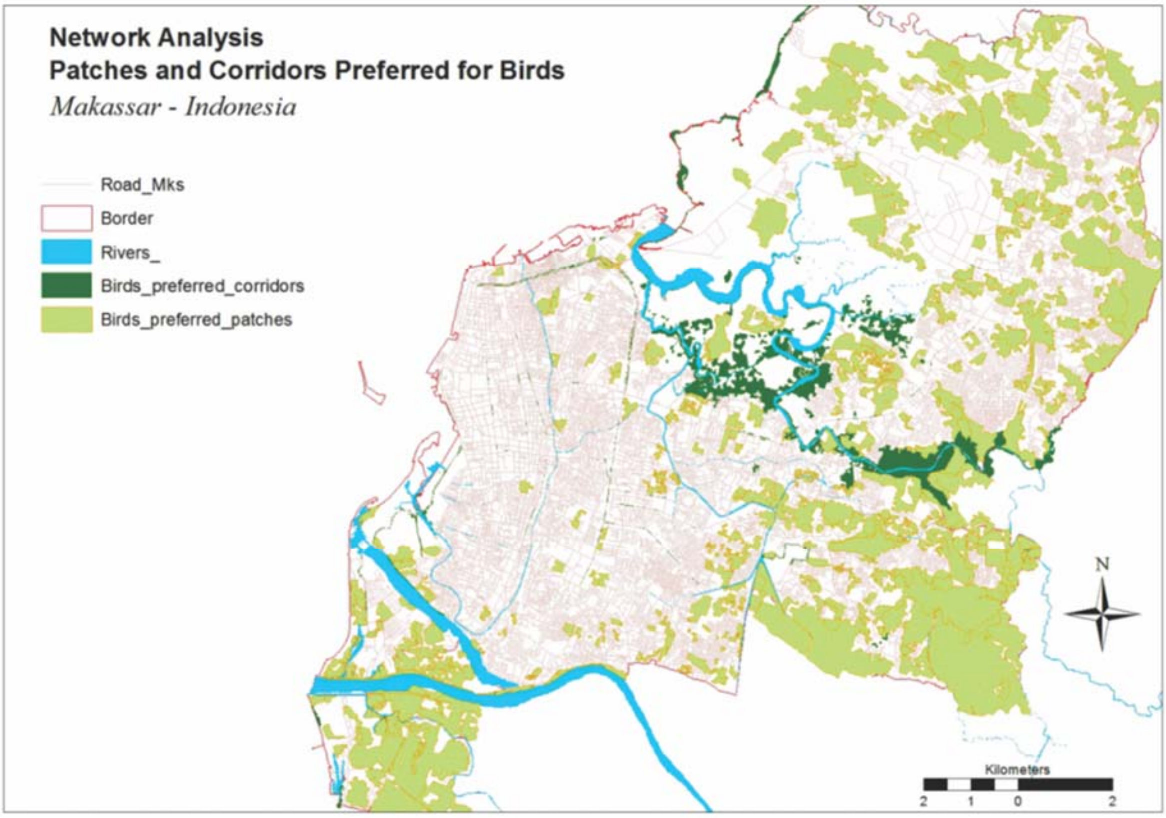

Figure 8.10. Preferred patches and corridors in Makassar for accommodation of birds disregarding land status

8.3. Filtering spaces by quality: including size and land status in biodiversity considerations

This study used biodiversity assessment as the main tool for assessing spaces in Makassar. The use of this method is sufficient for an urban context as the requirement was to obtain the state of general plant biodiversity. In addition to this, further space assessment was made taking urban birds as an alternative consideration as explained in the previous section. A study by Billeter et al (2008) concluded for areas where large bio-geographical variation of species exists, no single species group can be used to determine the existence of other species groups. This is the case for pristine natural areas, but in the urban context the condition is different. A high variation of species living in an environment where humans are dominant cannot be expected, since humans tend to impose disturbances (Tayyebi, 2012). In fact human initiated development is the main cause of habitat destruction (Memmott et al., 2005), homogenisation and fragmentation (R. H. G. Jongman, 2002), and occurs as a consequence of socioeconomic development and creation of infrastructure for human needs (Pattanavibool et al., 2004). These factors could all lead to biodiversity impairment. Makassar is no exception as fast development has taken over areas along its fringe. Therefore it was necessary to perform the biodiversity assessment already described. However, in order to procure a deeper analysis results, two additional considerations are added to filter spaces in the city of Makassar.

The first additional aspect to consider is land status. According to Indonesian regulations for urban spaces, land status refers to ownership, and recognises two types: private and public. The Minister of Public Works, (2008) provides definitions of both. Private space is any space that belongs to an individual or institution and which has use limited to the owner or authorized groups. The common forms are private garden, house yard, and corporate property yard, all of which can be left empty or planted. Public space, however, is any space that belongs to and is managed by the local authority, and which exists for and is used by the general public interest.

This study further elaborates land status into five groups: public space, state land, institutional ground, private space and corporate space. Having only two types looks too coarse and contains overlapping quality and functionality. Field observation also suggests that what is described as public space according to the government could be too general. For example a public park and an area of marshland or swamp by the riverside are both owned and controlled by the government, hence according to government regulation both are classified as public space. This is ambiguous because public space in many definitions refers to space that has special functions for people, such as recreational use, hence it should be accessible and have aesthetic qualities. Marshland on the other hand is completely beyond such functions. In terms of a management approach, these two spaces are also very different. Therefore, this study further distinguishes public space and introduces a category of state land. In this case marshland is categorized as state land. This distinction also provides an indication for further analysis in terms of human disturbance level on space type. In this case, for example, marshlands can be assumed to have levels of human disturbance that are much smaller than other public spaces like a public park, and therefore may have a better potential for being an ecological spot.

Institutional ground is also considered to be a separate land status category, to accommodate one type of typology in the study for which there is a better chance in terms of management for it to be included as urban green space. This is because it is practicable for the government to work with a range of institutions in preserving green spaces which are part of an institutional facility. One clear example of this is the existing nomination of campus grounds in Makassar (Hasanuddin University) as an official urban forest of the city (Antaranews, 2010).

Private and corporate ownership of spaces are separated mainly to reflect an observation in terms of land-use. In general corporate spaces are business and commercial grounds, and they belong to a corporation or combination of several individuals. In contrast, private space refers to small scale individual property, such as house yards and inter-house spaces. Both, however, possess similar difficulty in terms of management as it is unlikely the government will impose regulations upon them. Despite this, their existence is acknowledged and 'recommended' in the regulations of the Public Works Ministry (2008).

The second additional aspect of consideration is the patch size. According to Cook (2002), the sizes of patches and corridors are among the criteria used to assess an urban ecological network as the larger patches have the potential for preservation of greater areas of interior habitat. Forman (1995) furthermore listed the ecological values of both small and large patches and Cook (2002) concluded that large patches come with large benefits and small patches provide small supplementary benefits.

Another thing that might be important to acknowledge regarding patches is the kind of patch found in the study location. Dramstad, Olson, & Forman (1996) divided patches into four groups:

1) *remnants*, indicating the remains of extensive types of natural feature such as wood lots within agricultural fields;

2) *introduced*, meaning a patch which is established and not derived from any previous original features, such as a small pasture area within a forest;

3) *disturbance*, meaning a patch which was formed following change in coverage structure due to interruption by external or internal forces and which occurs naturally or artificially, such as a burned area in a forest;

4) *resources*, meaning a patch which carries special value and which is distinct and in contrast with its surroundings, such as a wetland area in a city.

Although this classification of patches was not used in this study, it is observable that the city of Makassar is dominated by the ‘introduced’ type of patches. Falling into this category are all built parks, corridors, farms, and fishponds. The other types available are ‘remnants’ (bulk of nypa palms along the sides of the main river) and ‘resources’ (some wetlands in the city). It would be an interesting analysis possibly leading to further research to focus on assessing all patches according to this classification, including trying to map their connection and network potential. However, this is beyond the scope of this research.

In this research a patch in Makassar is defined as a homogenous area which is different from the adjacent land coverage (Richard T. T. Forman, 1995). The size of a patch also varies, and this study has included all observable spaces in the inventory because patches may be as large as a national forest, or as small as a single tree (Dramstad et al., 1996).

The range of size for patches is different for different target species or biodiversity. The USDA guidelines (Bentrup, 2008) suggests that the different sizes of patch have potential to accommodate different levels of species. It is important to note that the biodiversity assessment in this study was mainly related to plants and no observation was made on animal species. Hence the sizes of area here need to relate to corresponding conditions. For example an area of 2 hectares with dense vegetation of various structures would serve better in terms of biodiversity than 5 hectares of open grassland. Therefore the size of area suggested needs to be related to the conditions necessary to harbour specific species as an indicator. The complete example ranges are presented in Table 8.10.

Table 8.10. Example ranges of minimum patch area for specific species taxa

Taxa	Patch Area (ha) (USDA (Bentrup, 2008))	Corridor width (m)			
		USDA (Bentrup, 2008)		Dutch context (Rooij, Sluis, & Steingrover, 2003)	
		Minimum recommended	Upper end recommended	Minimum width	Dispersal accommodating width
Plants	2.02 ha to ≥ 101.17	0 – 30.48	30.48 – 100.58		
Invertebrates	4.65 m^2 to ≥ 1.01	0 – 30.48	30.48 – 60.96		
Reptiles and amphibians	1.2 ha to ≥ 14.16	0 – 30.48	30.48 – 182.88	15	25
Grassland birds	4.9 ha to ≥ 54.6	0 – 30.48	30.48 – 100.58		
Waterfowl	≥ 4.9 ha	0 – 30.48	30.48 – 100.58		
Forest birds	2.02 ha to ≥ 38.5	0 – 60.96	60.96 - 1609.34		
Small mammals	1.01 ha to ≥ 10.12	0 – 58	58 – 100.58	0 – 15	15 - 50
Large mammals	16.19 ha to ≥ 518	0 – 100.6	100.6 - 2414.02	15 – 200	200 - 1000
Large predator mammal	906.5 ha to ≥ 220149	0 – 100.6	100.6 - 4828.03		

From Table 8.10. the designated taxa and area means the patch has the potential to harbour a specific group of species given that other requirements are fulfilled. The highest potential spaces for an ecological network are determined as a minimum of 2 hectares to set a target for proper ecological spots in an urban area where common and appropriate species can thrive. The target species are vegetation, invertebrates, small reptiles and amphibians, forest birds and small mammals. The smaller the area the smaller is the range of species that can be expected.

As for corridors, based on the inventory and mapping for Makassar, it is hard to find corridors with reasonable width for a good corridor. Even corridors which are formed by remnants of natural corridors alongside the main river in the city have inconsistent width as a result of fragmentation. Nevertheless however narrow the corridors are, their existence is still acknowledged and assessed accordingly with their other potential values.

On the other hand, ecological corridors according to Guidelines for Buffers, Corridors, and Greenways of USDA General Technical Report SRS-109 (Bentrup, 2008) should be a feature that facilitate species movement as well as provide potential habitat. They need to be wider as the length increases or when the landscape is dominated by humans, something that occurs in Makassar.

Therefore, according to observation regarding the naturalness of spaces in Makassar as analysed in this thesis, it appears unlikely there are spaces that could serve as proper ecological habitats for a viable network. However, size consideration is important for this feasibility analysis. The preservation of current spaces of preferred size, despite their poor physical condition for an ecological spot, would at least prepare sizeable spots for future habitats, given that improvement in physical quality in favour of ecology could be achieved in such spaces.

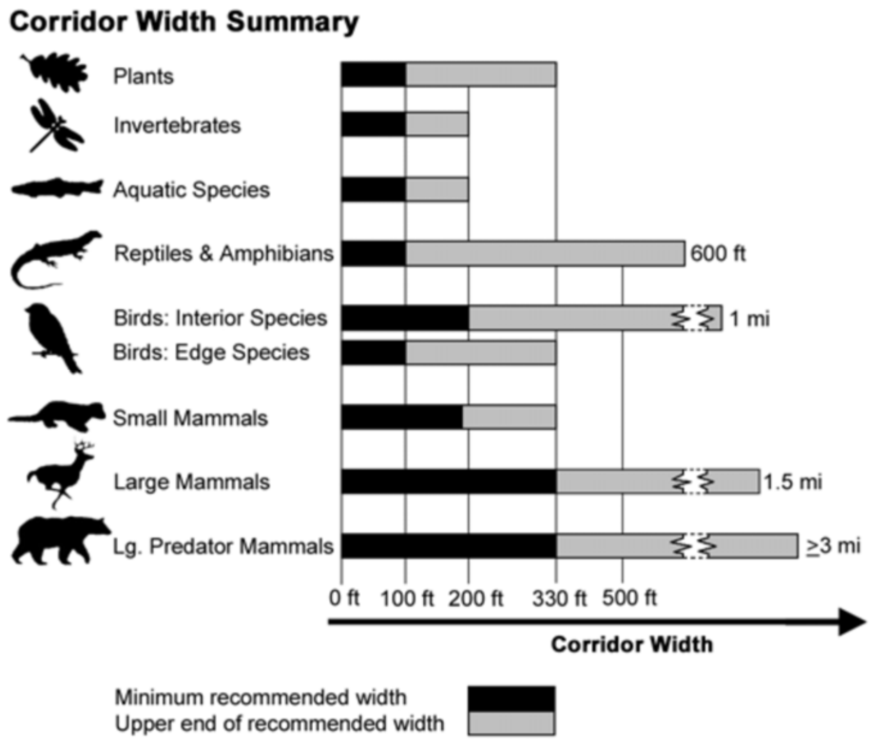

Figure 8.11. Suggested corridor widths according to USDA
(Source: Bentrup (2008))

Based on the three main considerations above (biodiversity, land status, and patch size), this study proposes the separation of spaces into different classes based on their feasibility level for inclusion into a green network, or for conversion into viable urban habitat. Two descriptive terms are proposed: ‘eco’ and ‘green’. ‘Eco’ refers to spaces with higher potential for their value in being green, and possibly ecological, because their vascular plant biodiversity is high, but not necessarily sufficient for an ecological spot. ‘Green’ refers to spaces which have more quality as green and vegetated area, and are unlikely candidates for ecological spots. Both terms, with an improvement and management policy, constitute spaces of potential habitat as the basis for ecological spots. However, the performance level of both terms when considering the three aspects mentioned before, will have significance for their inclusion in and compatibility with any ecology concept and networking plan.

It is however important to understand that the use of the terms ‘eco’ and ‘green’ does not necessarily suggest the spaces attributed to the terms have the quality of spaces for ecological network (eco) or green network (green). The terms are indicative of the quality ranking of the spaces relative to the three aspects discussed here, where the ‘eco’ group is seen as better than the ‘green’. Both consist of three different levels as seen in Table 8.11.

Table 8.11. Different feasibility preferences for groups of spaces

Class of space	Feasibility level as ecological spot	Description	Aspects of Consideration			Dominant typology/ies
			Biodiversity-led score	Land status	Expected minimum area	
Eco #1	Most ideal spaces	Spaces which are very likely to be included in some form of green spaces network	High	Public or state-owned land	≥ 2.02 hectare	River corridor, wetland
Eco #2	High potential	Spaces which require government efforts to apply improvement policy	High	Public or state land,	< 2.02 hectare	Institutional space
				Institutional ground	≥ 1.01 hectare	
Eco #3	Medium potential	Spaces which require specific management arrangement and preservation policy	High	Institutional ground	< 1.01 hectare	Institutional space, empty field
				Private or corporate	≥ 1.01 hectare	
Green #1	Low potential	Could be made green but lacking in quality for ecological spots, and also requiring policy arrangement	High	Private or corporate	< 1.01 hectare	Public open/green spaces, public field, empty field
			Medium	Public or state land, Institutional ground	any	
Green #2	Less Likely	Unlikely for ecological patch or corridor, yet having potential for green connection lines or patches with improvement in physical condition and mutual arrangement for private/corporate spaces	Medium	Private or corporate space	any	Road corridors (primary, secondary and tertiary), fish ponds
			Low	Public or state land, Institutional ground		
Green #3	Unlikely	Biodiversity and management possibility are poor	Low	Private and corporate	any	Tertiary road corridor, commercial space

Another aspect that could strengthen the feasibility of the space is its compliance with long term government plans. Spaces identified by this study inventory were also overlaid on the government spatial plan map. The city council of Makassar in their official website propose long term spatial planning up to 2016 (Makassar City Council, 2009b). According to the plan, areas of the city have been classified into areas of development and areas of integrated zones for specific purposes. For green space development, three aspects need to be considered in order to synchronize the existing and potential spaces with the spatial plan of the city. These aspects are: city zoning, area of specific purpose development, and direction for green area development. Based on these considerations identified spaces need to comply with this long term plan to ensure a continuous viable network, which will be less likely to suffer from conversion due to development and government initiated urban growth. The compliance level was an implied criterion related to three aspects:

1) government attitude toward their future status;

2) their location in regard to government development zones;

3) and their location in regard to government green plan zones.

For example the most ideal spaces are considered highly compliant as they are official preserved spaces outside a significant physical and infrastructure development zone and within an area designated for 50% or more green spaces. Private or corporate spaces generally are not taken into the government inventory of spaces, although their existence is described in the official land-use map and contributes to the government's target for a long term green development plan. Unfortunately without a policy based approach the government will have little or no control over these spaces, which means they can be developed in the future beyond the government projected use. This study therefore takes these non-state owned lands into account, assuming them to have potential and that there will be a new policy approach to their management.

Figure 8.12. Identified spaces overlaid on government green development plan (Makassar City Council (2009b))

Figure 8.12. shows the city of Makassar is planned to have several zones based on a target percentage of green space land cover by 2016. Based on land coverage related to the space inventory in this study, there is a possibility of achieving this target. It seems only in the downtown areas, where the target is 20% green areas, will this be difficult to achieve. This is a highly urbanized part of the city, and unless extreme actions are taken by the government (such us purchasing private properties to be converted into parks) the target seems virtually impossible. However in the fringe, the plan might be achievable under two conditions: the current available spaces are preserved, and other spaces which have not been officially identified due to land status and ownership are included. In fact the number of these 'unofficial spaces' is enormous. Therefore, the authority needs to

formulate a policy to work together with the owners of private and corporate land in order to include their spaces as part of the city's green spaces. The government could learn from Japan where in places private yards and spaces are under the management of a government appointed agency (Carmona et al., 2004).

This study however, does not take this suggested course of action into account in its feasibility consideration. This is mainly because there is insufficient supplementary information regarding government plans apart from what can be extracted from the map. There is also ambiguity in the government's identification of green space as only government managed spaces are included, whereas in their spatial plans, such as the green plan shown in Figure 8.12, all spaces identified in the city land use map are included whatever their ownership. The green areas shown in Figure 8.12 were re-mapped in this study. Although all digitized spaces look similar to the official land-use map, the map developed for this study is used as it is more up to date and corrects some inaccuracies found in the official government map.

8.3.1. The most ideal spaces (Eco #1 spaces)

It is unfortunate that there are not many spaces of this type in Makassar. The types of land use which belong to this category are presented in Table 8.12.

Table 8.12. Spaces considered to have the best potential (Eco#1 space) for an ecological/green network in the city of Makassar

Type of land-use	Number of Patches	Sum of Area (ha)	Average Patch Size	Minimum Patch Size	Maximum Patch Size	Percentage	Typology group/s
Green space	1	2.03	2.03	2.03	2.03	0.26	Empty field
Mangrove	1	6.99	6.99	6.99	6.99	0.89	River corridor
Marshland	8	196.77	24.60	2.23	134.69	24.99	Wetland
Nypa palm	4	503.09	125.77	3.10	462.41	63.89	River corridor, Wetland
Riparian zones	1	9.22	9.22	9.22	9.22	1.17	River corridor
River/stream corridor	1	2.45	2.45	2.45	2.45	0.31	River corridor
Stream corridor	1	3.17	3.17	3.17	3.17	0.40	River corridor
Swamp and lake	1	44.05	44.05	44.05	44.05	5.59	Wetland
Swamp, marshland, water catchment area	1	13.68	13.68	13.68	13.68	1.74	Wetland
Swamp, river bank	1	3.11	3.11	3.11	3.11	0.39	Wetland
Water catchment	1	2.82	2.82	2.82	2.82	0.36	Wetland
Grand Total	**21**	**787.37**	**37.49**			**100.00**	

As presented in Table 8.12, and seen in Figure 8.13, eco#1 space is mainly the remnant of the river corridor that runs along the River Tallo, the main river in Makassar. The corridor itself has undergone severe fragmentation due to land conversion for cultural activities such as establishment of fish ponds and farm fields. The authority of Makassar includes this type of space as being under their control yet this cannot explain the land conversion, which according to field observation of the fish ponds and fields along the river (previously assumed to be natural river corridors) are all privately managed. This leads to the assumption that the ownership status of these parts of river corridors have been shifted, suggesting that the government allows people to buy land along the river, although these are areas which should be preserved. Only one part of the river corridors in the District of Tallo (Lakkang) has been pronounced a conservation area in the official government spatial planning 2016 (Anonymous, 2010). Although the document has not been approved by parliament, the classification of the Lakkang region as a conservation area shows the good intention of the local government to preserve the natural attributes and qualities of the location. The inclusion of the remaining corridors into the government inventory gives hope that the government has the intention to preserve whatever remains of the river corridors. Otherwise the remaining corridors (Figure 8.13.) will probably have other uses in the near future, as according to Mörtberg (2009b, p. 439), “remnants of natural habitats have often been considered as reserve land for future exploitation”.

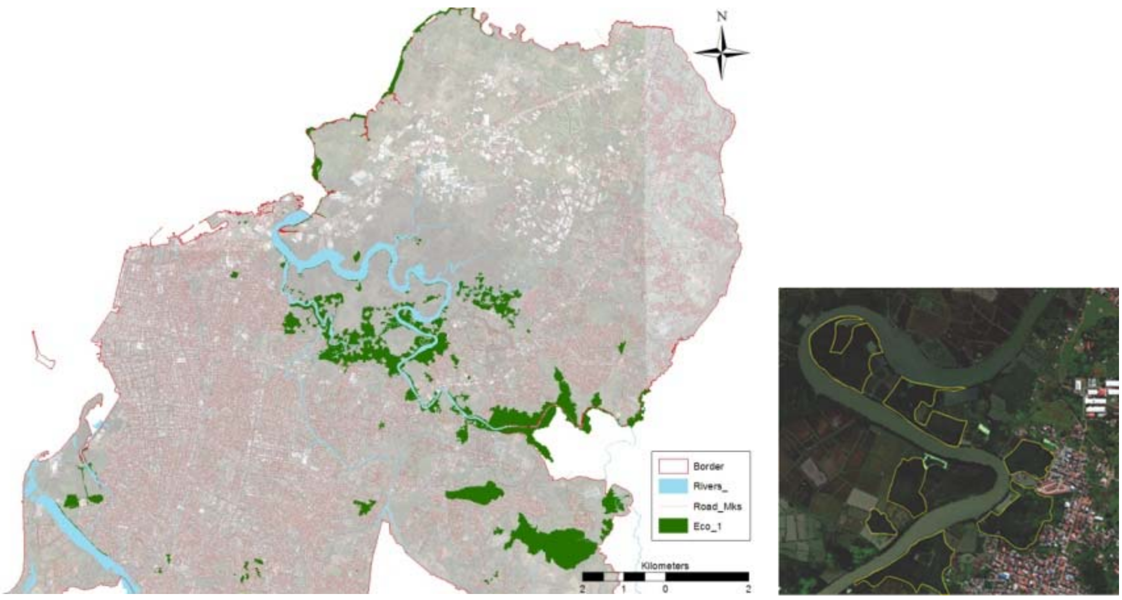

Figure 8.13. Spaces considered to have best potential for ecological spots (Eco#1) (left), Fragmentation of the corridors (right). Fragmented spaces outlined in yellow

As shown in Figure 8.13, corridors along the main river are not continuous, but consist of many patches. In the maps they are assumed to be a long continuous patch and not mapped separately because distances between patches are very short. Hence Table 8.12 shows almost all land use types along the river are not represented by a large number of patches. This happens because initially they were a large, complete patch that has been fragmented by cultural activities such as agriculture and fish rearing. What remain as corridors of this type are generally a 'connection' between Nypa palm patches and a number of swamps.

This study was unable to find information about animal biodiversity in the spaces alongside the Tallo River. From the picture, it is observable that the corridor has been encroached on for various land uses. Mostly these are fish ponds and farm fields but residential areas also seem to be shifting closer to the rivers. Because of this fragmentation, the role of the corridor as habitat for various water species has probably been degraded, and might not be functioning at its real potential. However, given that the government has started to pay attention to the rivers, it seems the city would like to see the corridor of its main river returned to serve as an ecological conduit and network component.

Because this corridor is the only natural remnant existing in the city, it is very important to ensure its preservation if it is designated for inclusion in a greenway, ecological or a green network.

8.3.2. High potential spaces (Eco #2 spaces)

The fact that institutional spaces such as campus grounds and government facilities have been announced as official green spaces and urban forest in the city, with proper management, confirms the likelihood of institutional spaces being in line with the government proposal. Therefore, institutionally managed spaces with a high level of biodiversity fall into this category. The following table shows the existence of such spaces in the city of Makassar.

Table 8.13. Spaces with high potential (Eco#2 space) in Makassar

Type of land-use	Number of Patches	Sum of Area (ha)	Average Patch Size	Minimum Patch Size	Maximum Patch Size	Percentage	Topology Group/s
Campus ground	3	4.53	1.51	1.02	1.93	2.16	Institutional space
Cemetery	1	0.20	0.20	0.20	0.20	0.10	Empty field
Empty ex-terminal space	1	0.91	0.91	0.91	0.91	0.43	Empty field
Empty/open field/space	7	53.22	7.60	0.15	35.13	25.38	Empty field
Institutional yard	1	5.78	5.78	5.78	5.78	2.76	Institutional space
Marshland	6	6.90	1.15	0.64	1.58	3.29	Wetland
Military	1	2.49	2.49	2.49	2.49	1.19	Institutional space
Office yard	1	1.30	1.30	1.30	1.30	0.62	Institutional space
Park	4	17.62	4.40	1.02	8.59	8.40	Institutional space
Property open space	1	2.81	2.81	2.81	2.81	1.34	Institutional space
Wet patch-risk open space	1	0.94	0.94	0.94	0.94	0.45	Empty field
School yard	1	1.56	1.56	1.56	1.56	0.74	Institutional space
Swamp, river bank	12	7.79	0.65	0.22	1.53	3.72	Wetland
Urban forest	3	102.80	34.27	9.80	48.50	49.03	Institutional space
Water catchment	1	0.82	0.82	0.82	0.82	0.39	Wetland
Grand Total	**44**	**209.66**	**4.76**			**100.00**	

The largest patches identified in this class are urban forests (49.03%), and as mentioned some campus grounds have been classified as such. The other high potential spaces are all also institutional space with various forms of land use. Again the city has few spaces like this and even though they are all potentially manageable by the city council they are insufficient for creating a flowing network (Figure 8.14.)

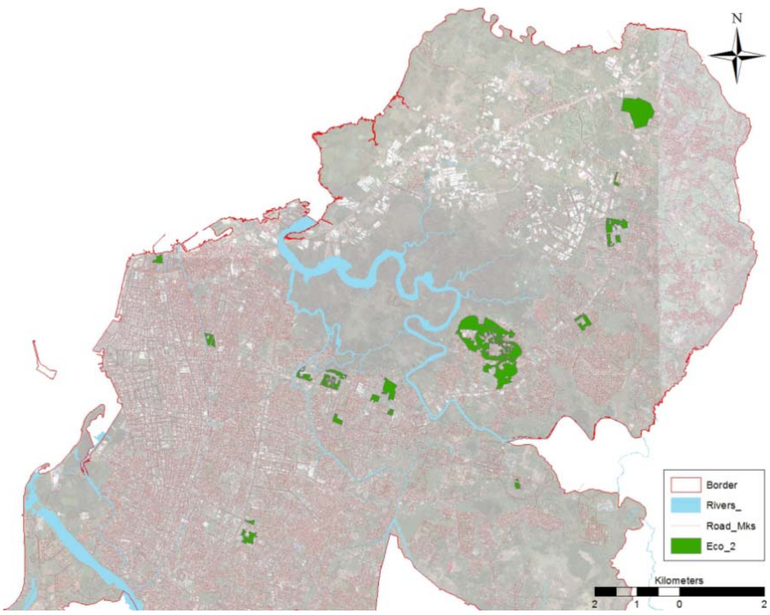

Figure 8.14. High potential spaces (Eco #2) in Makassar

Patches of this class are separated, yet connection is still possible by utilizing low scoring corridors or patches that exist between them.

8.3.3. Medium potential spaces (Eco #3 spaces)

Spaces which are considered eco #3 are all high biodiversity institutional spaces smaller than 1.01 hectares, and all private and corporate spaces larger than 1.01 hectares.

Although all the spaces in this category have reasonably high levels of vascular plant biodiversity, their management, or lack of it, may be a problem. Institutional spaces as described earlier are most likely to be managed, but private and corporate space may require special schemes and arrangements between the owner and the government. Such spaces often found in Makassar are agricultural fields.

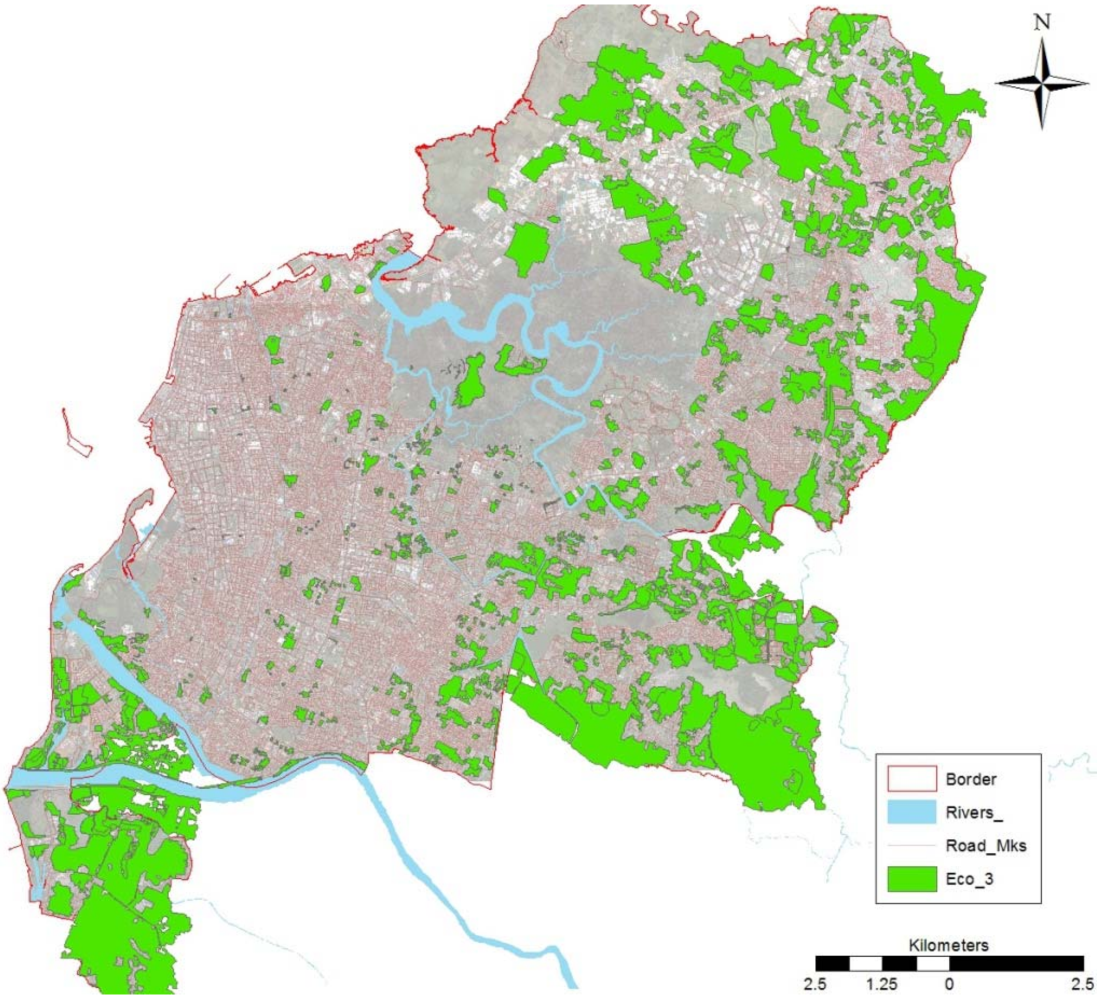

Figure 8.15. Medium potential spaces (Eco #3) in Makassar

Table 8.14. Spaces with medium potential (Eco#3 space) in Makassar

Type of land-use	Number of Patches	Sum of Area (ha)	Average Patch Size	Minimum Patch Size	Maximum Patch Size	Percentage	Typology group/s
Agriculture/farm field	101	903.66	8.95	1.02	84.90	20.94	Urban farm
Building open space	3	1.70	0.57	0.22	1.06	0.04	Institutional space, Empty field
Business yard	1	0.17	0.17	0.17	0.17	0.00	Institutional space
Campus garden/park	5	1.74	0.35	0.09	0.97	0.04	Institutional space
Campus ground/yard	5	1.78	0.36	0.17	0.56	0.04	Institutional space
Church yard	1	0.16	0.16	0.16	0.16	0.00	Institutional space
Empty/open space/field	158	593.22	3.75	0.19	30.71	13.75	Commercial space, Empty field, Un-built space, Institutional space, Public field
Empty space of private company	3	3.73	1.24	0.09	2.37	0.09	Empty field, Institutional space
Fish pond	1	2.91	2.91	2.91	2.91	0.07	Fish pond
Fish pond, farm	1	5.78	5.78	5.78	5.78	0.13	Urban farm
Green space	18	39.82	2.21	0.82	8.17	0.92	Empty field, Institutional space
Marshland	31	157.93	5.09	1.02	45.40	3.66	Wetland
Marshland, inter-house space	3	10.13	3.38	1.55	6.46	0.23	Wetland
Military complex	2	1.54	0.77	0.40	1.14	0.04	Institutional space
Mosque garden	1	0.27	0.27	0.27	0.27	0.01	Institutional space
Office yard/open space	6	1.78	0.30	0.04	0.53	0.04	Institutional space
Paddy field	42	1930.06	45.95	1.32	392.52	44.72	Urban farm
Paddy field and farm/mix crop	18	482.66	26.81	3.35	102.63	11.18	Urban farm
Park	18	5.34	0.30	0.02	0.70	0.12	Institutional space
Parking and service area	1	0.20	0.20	0.20	0.20	0.00	Institutional space
Plantation	1	17.92	17.92	17.92	17.92	0.42	Urban farm
Private office empty field/yard	2	2.17	1.09	0.08	2.09	0.05	Empty field, Institutional space
Property garden/park	9	2.34	0.26	0.14	0.56	0.05	Institutional space
Property open space, sporting ground	11	2.87	0.26	0.07	0.54	0.07	Institutional space
Puddled area	1	1.31	1.31	1.31	1.31	0.03	Wetland
Residential empty space	23	96.90	4.21	1.13	11.33	2.25	Empty field
School green yard	2	0.21	0.11	0.10	0.11	0.00	Institutional space
School yard	5	1.49	0.30	0.11	0.49	0.03	Institutional space
Shallow lake	1	6.75	6.75	6.75	6.75	0.16	Wetland
Swamp	2	3.11	1.56	1.03	2.08	0.07	Wetland
Urban forest	1	0.40	0.40	0.40	0.40	0.01	Institutional space
Water catchment	2	35.61	17.81	9.43	26.18	0.83	Wetland
Grand Total	**479**	**4315.66**	**9.01**			**100.00**	

Most urban farms with their paddy fields and mixed crop fields belong to this group. What lowers their level of preference is the status of ownership. Policy change could do something for their optimization. Improvement in the physical appearance of agricultural areas has been proposed by many studies. Suggested ways to improve agricultural fields in Makassar, for example, include applying agroforestry principles such as wind breaks and riparian buffers (Idassi, 2012).

8.3.4. Low potential spaces (Green #1 spaces)

Table 8.15. Spaces with low potential (Green#1 space) in Makassar

Type of land-use	Number of Patches	Sum of Area (ha)	Average Patch Size	Minimum Patch Size	Maximum Patch Size	Percentage	Typology group/s
Cemetery/Grave yard	53	72.64	1.37	0.03	23.13	20.88	Public open/green space
Dam corridor	1	3.66	3.66	3.66	3.66	1.05	Stream/canal corridor
Residential open/empty space	51	20.84	0.41	0.11	0.98	5.99	Empty field, Unbuilt space
Empty/open space/field	162	127.56	0.79	0.08	40.42	36.66	Empty field, Institutional space, Unbuilt space, Public field, Public open/green space
Farm field/mix crops	12	7.65	0.64	0.18	0.97	2.20	Urban farm
Green space/Green empty space	17	8.62	0.51	0.14	0.97	2.48	Empty field, Public open/green space, Unbuilt space
Highway open space	2	0.08	0.04	0.02	0.06	0.02	Public open/green space
Marshland	15	9.23	0.62	0.23	0.95	2.65	Wetland
Office yard/green yard	5	0.75	0.15	0.06	0.26	0.22	Public field
Paddy field	1	0.85	0.85	0.85	0.85	0.25	Urban farm
Park, small park	51	22.68	0.44	0.02	4.44	6.52	Commercial space, Institutional space, Public field, Public open/green space
Park and corridor	1	0.18	0.18	0.18	0.18	0.05	Public open/green space
School field/yard	3	1.15	0.38	0.14	0.56	0.33	Public field
Sports field	3	6.89	2.30	0.89	5.02	1.98	Public field
Stream corridor	1	0.88	0.88	0.88	0.88	0.25	Stream/canal corridor
Swamp	2	0.99	0.50	0.43	0.56	0.28	Wetland
Urban forest	5	63.28	12.66	0.64	58.18	18.19	Public field, Public open/green space
Grand Total	**385**	**347.92**	**0.90**			**100.00**	

Spaces in this category may have high vascular plant biodiversity but their size is relatively small, and they are likely to have management problems as well as ownership issues. State land or public spaces as well as institutional spaces which belong to this group are those with medium plant biodiversity level.

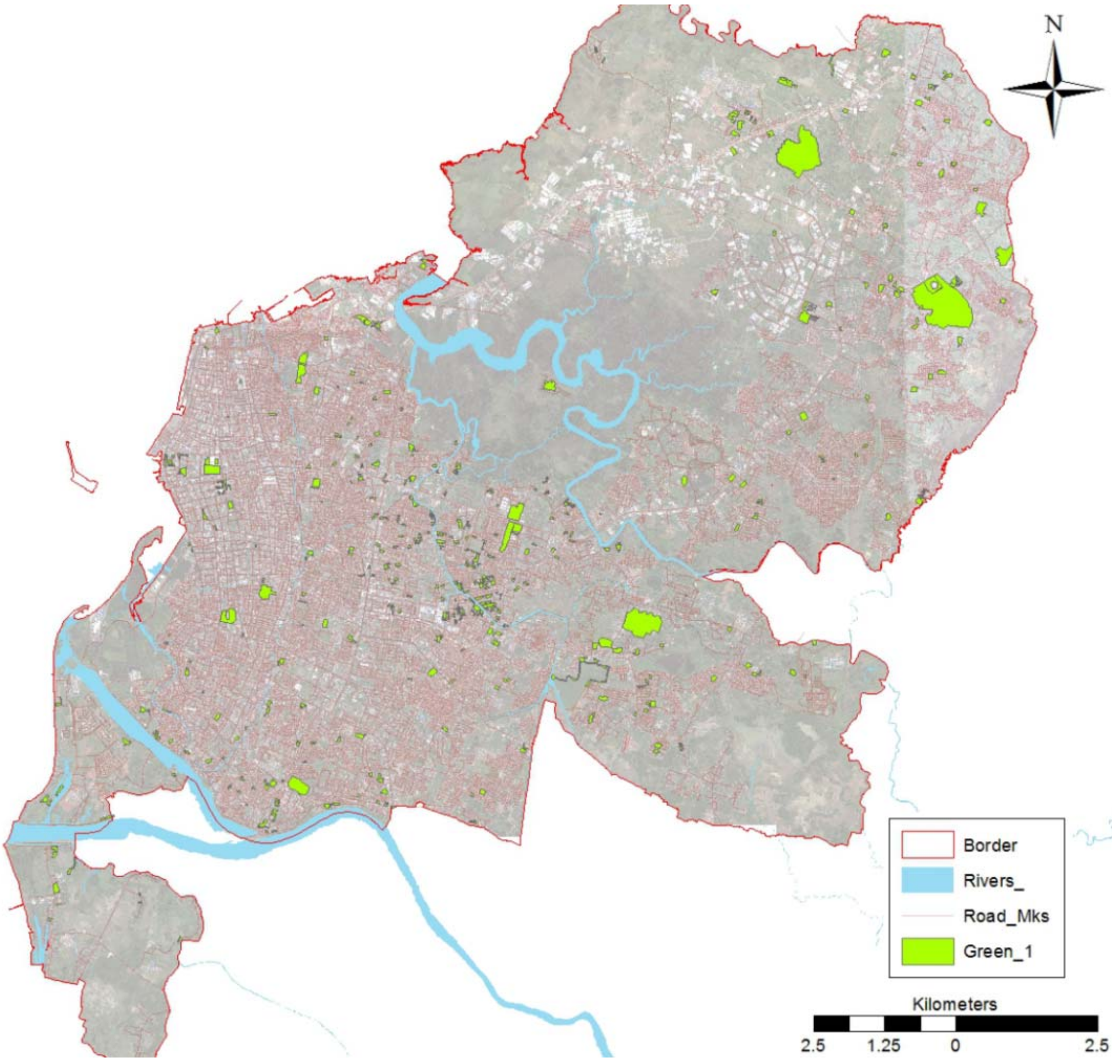

Figure 8.16. Low potential spaces (Green #1) in Makassar

8.3.5. Less likely spaces (Green #2 spaces)

Table 8.16. Spaces which are less likely for inclusion in an ecological network in Makassar (Green#2 space)

Type of land-use	Number of Patches	Sum of Area (ha)	Average Patch Size	Minimum Patch Size	Maximum Patch Size	Percentage	Typology group/s
Campus yard	2	0.26	0.13	0.01	0.25	0.01	Inter-house space
Dormitory yard	4	0.79	0.20	0.12	0.29	0.04	Inter-house space, Public field
Empty space	10	3.38	0.34	0.17	0.58	0.17	Commercial space, Public field
Fish pond	63	1876.26	29.78	0.10	303.52	94.95	Fish pond
Fish pond and farm	1	39.22	39.22	39.22	39.22	1.98	Fish pond
Green road corridor	74	13.09	0.18	0.02	0.68	0.66	Primary road corridor, Secondary road corridor
Green space	4	7.44	1.86	1.34	2.53	0.38	Public open/green space
Neighbourhood park	2	0.30	0.15	0.15	0.16	0.02	Public open/green space
Office yard	3	0.56	0.19	0.18	0.20	0.03	Inter-house space
Open field	5	14.09	2.82	0.19	11.94	0.71	Inter-house space, Public field, Public open/green space
Park/Roadside park	24	3.91	0.16	0.01	1.56	0.20	Institutional space, Inter-house space, Public open/green space, Primary road corridor, Secondary road corridor, Tertiary road corridor
Public field	4	2.12	0.53	0.19	0.90	0.11	Public field
Road median	118	14.61	0.12	0.00	2.16	0.74	Primary road corridor, Secondary road corridor, Tertiary road corridor
School greenery	3	0.06	0.02	0.01	0.03	0.00	In-property corridor
School yard	1	0.02	0.02	0.02	0.02	0.00	Secondary road corridor
Grand Total	**318**	**1976.12**	**6.21**			**100.00**	

Most space in this category is to do with fish ponds. Their monoculture nature lowers their biodiversity score. Despite scoring medium biodiversity, fish ponds have potential due to their significant area, (94.95% of the Green#2 space group) and their location close to rivers where the more natural remnants in the city are mostly found.

From an ecological point of view, it might be best to see these fishponds converted into well vegetated areas or into fields which still carry ecological value. However, it is important to understand the significant productivity of both, which contribute to the food supply for the city. In 2010, urban farms in Makassar produced more than 17 thousand tons of rice, not to mention other commodities, while inland fishery produced 544 tons of fishery products. This was only 5% the productivity of marine fishery, yet still of high significance for the city (Makassar Statistic Board, 2012). This fact implies that total conversion of use would not be a wise option. However, there are ways of improving the physical condition of fishponds to make them have more ecological significance. Similar to border plants in agriculture fields, the edges of fishponds can also be made green by planting trees and other types of vegetation.

Apart from fishponds with their potential link to river corridors, this group contains road corridors and roadside parks. Although all are low in biodiversity they should be considered and planned for future improvement. Lessons from many developed countries show the inclusion of road corridors as important for greenways.

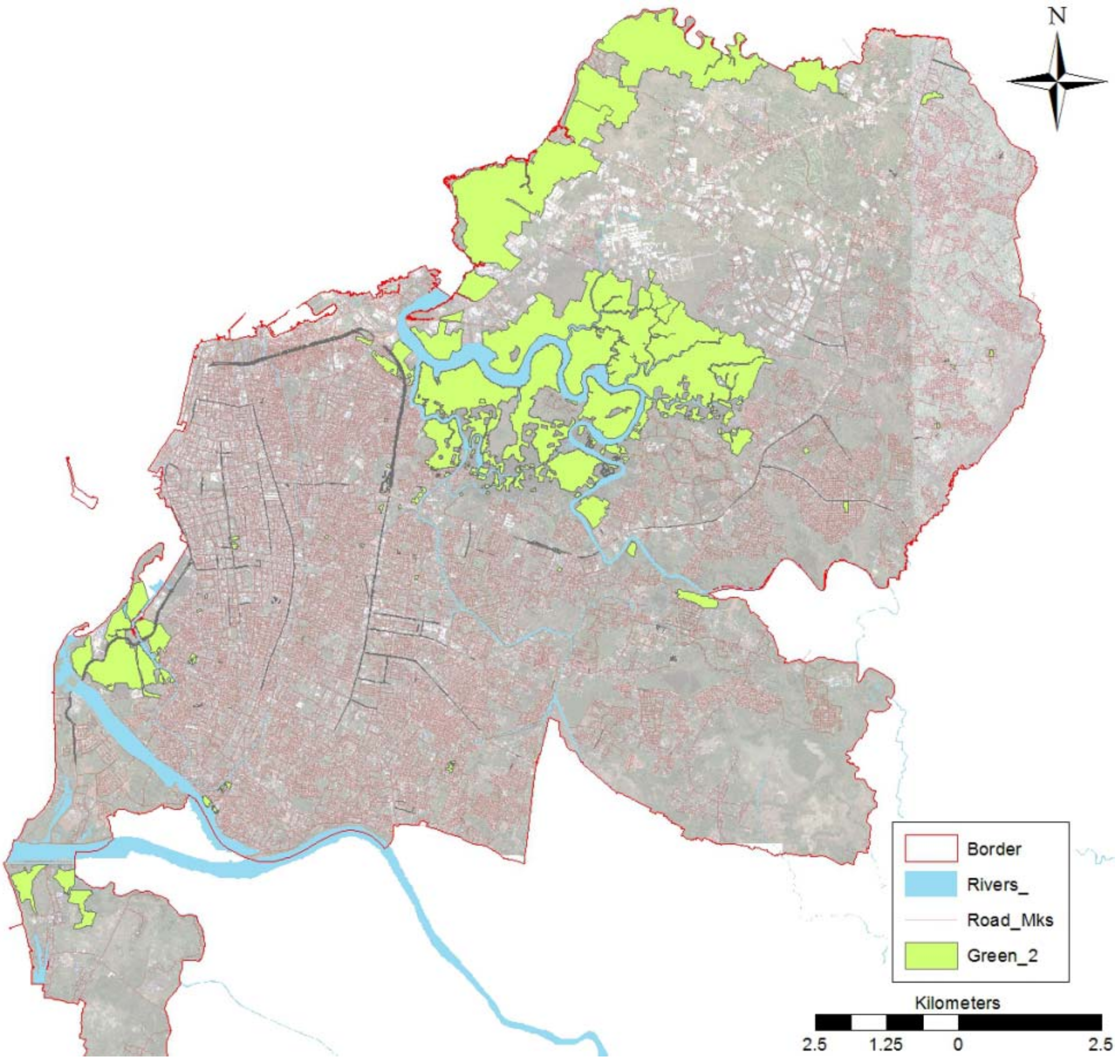

Figure 8.17. Spaces less likely to be part of an ecological network in Makassar (Green #2)

8.3.6. Unlikely spaces (Green #3 spaces)

Table 8.17. Spaces which are unlikely for inclusion in an ecological network in Makassar (Green#3 space)

Type of land-use	Number of Patches	Sum of Area (ha)	Average Patch Size	Minimum Patch Size	Maximum Patch Size	Percentage	Typology group/s
Business greenery	2	0.31	0.16	0.15	0.16	0.24	Commercial space, Inter-house space
Empty space	2	6.86	3.43	0.71	6.15	5.27	Commercial space
Industrial area	1	104.73	104.73	104.73	104.73	80.44	Commercial space
Industrial open space	1	1.58	1.58	1.58	1.58	1.21	Commercial space
Inter house-commercial space	1	0.72	0.72	0.72	0.72	0.55	Commercial space
Roadside small park	3	0.12	0.04	0.00	0.08	0.09	In-property corridor, Inter-house space, Tertiary road corridor
Residential area	4	14.24	3.56	0.88	5.11	10.93	Commercial space
Road median	14	1.47	0.11	0.01	0.64	1.13	Tertiary road corridor
Grand Total	**29**	**130.20**	**4.49**	**0.00**	**104.73**	**100.00**	

Low scoring spaces in terms of vascular plant biodiversity are not necessarily poorly vegetated. Some typologies such as inter-house space and all road corridors scored low because of the existence of built structures around them, yet they might still have significant vegetation. Therefore, under certain circumstance and with positive plans for their improvement, they could still contribute to a better urban environment in Makassar.

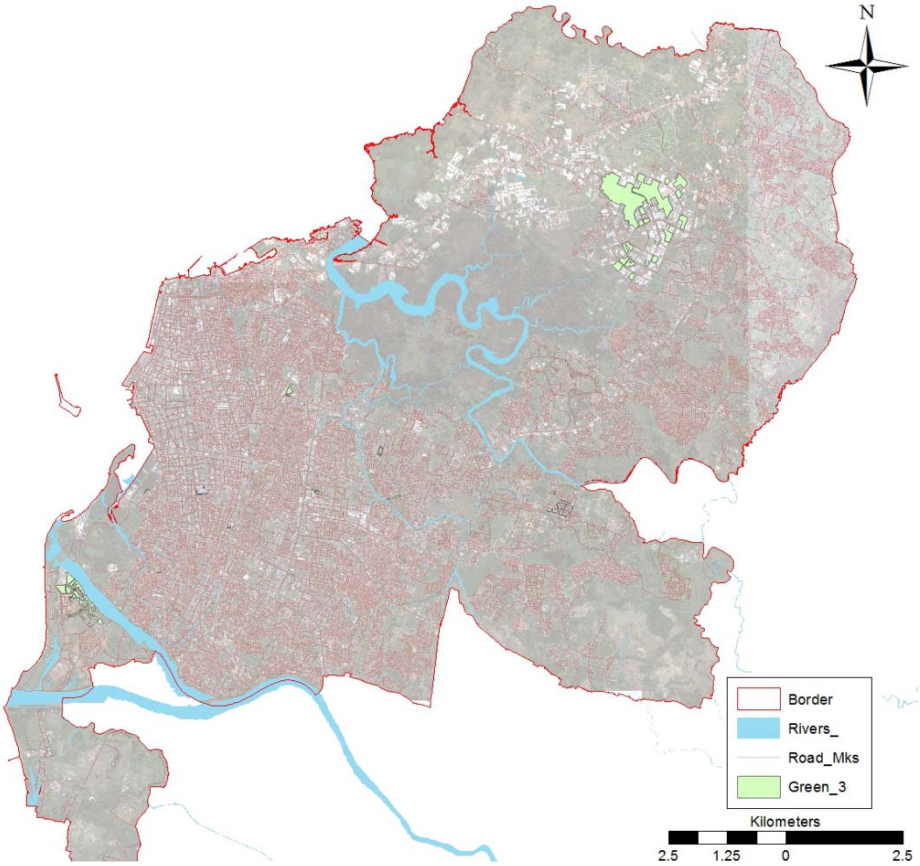

Figure 8.18. Spaces unlikely to be part of an ecological network in Makassar (Green #3)

Having the spaces classified as above leaves another question, about which are the most wanted spaces. Simply saying the eco#1 class is the most ideal is not enough for a city the size of Makassar for two main reasons. First, the total area of this group is only 4.5% of the city, and secondly the distribution of spaces with this classification is mostly along the main river, hence they need to be merged with other groups of space to obtain a better coverage for the whole city. Therefore, this study analyses the identified spaces using another approach, the results of which will be combined with the classification of spaces to produce the most preferred spaces for the city of Makassar. This will be presented in the next chapter.

8.4. Summary

This chapter discusses applying more filters in order to separate spaces with more desirable qualities prior to assessing whether spaces can be connected into some form of network. Plant biodiversity which was ascertained using the RBA was the base consideration for inclusion of spaces in this sense. With categorization, spaces could be divided into three biodiversity levels. Inspired by studies elsewhere, urban species also became an important factor to explore. In the context of Makassar urban birds were the most relevant species. The other two important factors are size of spaces and their status in terms of ownership. Size could affect the hosting capacity of the spaces whereas ownership relates to their future management. Biodiversity concerns plus the size and ownership considerations lead to the development of classes of space. Overlaying these maps reveals the spaces which meet all desired criteria and this will be discussed in the next chapter.

Chapter 9

Creating a Network from Analysis of Potential Spaces

This chapter looks at the possibilities for creating connections between spaces as a result of considering all aspects explained in Chapter 8. The connectivity of spaces in the form of a network has been studied in other places but under different conditions and considerations.

It is also important to see how any network in the city could be connected to existing more natural areas by looking at the network at a bigger scale through involving adjoining regions and regencies. This study uses the development area of the greater urban region of 'MAMMINASATA' (MAkassar, Maros, SungguMINASA-gowa and TAkalar) as the boundary for this bigger picture (See Section 4.6.). This development area has been officially acknowledged (Presidential decree, 2011), and is therefore seen as important for the integration of both development and green planning. Moreover, it is important to interconnect or at least prepare the readiness of sites within a certain region to accommodate ecological function as habitats for other regional sites, and even from different administrative or geographical areas (Opdam et al., 2006).

9.1. The most preferred spaces in the city

As explained in Chapter 8, this study has three basic considerations for the analysis of potential spaces. The first considers the quality of spaces based on biodiversity, with the second consideration taking a species indicator as the main reason for ranking spaces. The third consideration is land status and size, and together these result in a classification of preferred spaces. For this Makassar study, as in most urban studies, the common species indicator for environmental change in urban areas is birds.

Analysis of the quality of spaces produced the three best classes, termed 'eco' classes. These are considered to have the best quality of space for working towards a green or ecological network in the city. Having overlaid all classes of the first approach with the spaces obtained from the third approach (land status and size), it appears that a combination of the three best classes (Eco#1 to Eco#3) would best match the preferences map for birds.

Figure 9.1 shows the overlay of two maps representing the three approaches. The first map is based on bird preference spaces and the second includes only Eco#1, Eco#2 and Eco#3 spaces (the best three classes). The level of overlap is significant, leading to the conclusion that these two maps are the most appropriate to use as the basis for the creation of a possible network.

The overlapping spaces (the brown area of the map in Figure 9.1) are the ones considered as having most potential. This potential refers to the consideration of all the analysis stages in the previous chapter and hence would best be defined as spaces which have high plant biodiversity score, are preferable for urban birds, but which, concerning size, land status and physical appearance, might require specific management arrangements, improvement and preservation policies.

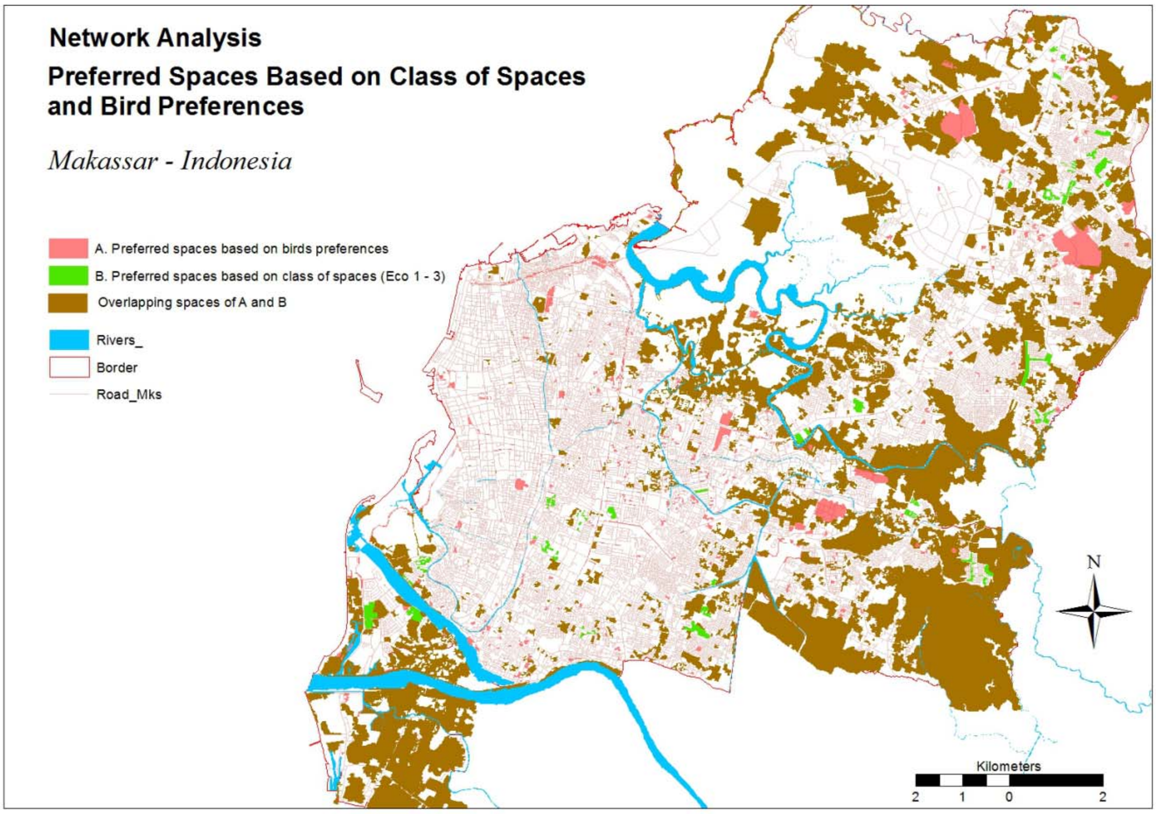

Figure 9.1. Preferred spaces from the overlay of class of spaces and bird preferences

The overlay gives the target spaces for proposing a better urban environment in Makassar in terms of ecology. These spaces are the ones recommended for the local authority to maintain, improve and utilize for improved ecology in the city. However, it does not mean other identified spaces in this study should be ignored.

Table 9.1 shows the land use types resulting from the overlaid maps, which will be further analysed for formation of a possible network.

Table 9.1. Preferred spaces from combining results of the three approaches

Land Use	Area (ha)	Percentage (%)
Agriculture field/Urban Farm	2848.28	61.69
Other building open space	0.64	0.01
Commercial/business open space	0.17	0.00
Campus ground/park/open space	8.05	0.17
Cemetery	0.20	0.00
Mosque/Church yard	0.43	0.01
Other empty field/space	619.65	13.42
Empty space in settlement/residential area	3.40	0.07
Golf course	10.02	0.22
Green space/park	56.22	1.22
Institutional yard	14.02	0.30
Military ground/ complex	4.02	0.09
Office yard/open space	5.25	0.11
Parking and service area	0.20	0.00
Building/property open/green spaces	8.02	0.17
Marshland, water catchment area	399.21	8.65
Riparian zones, river/stream corridor	461.22	9.99
School yard	3.26	0.07
Shallow lake	6.75	0.15
Swamp	64.74	1.40
Urban forest (including campus ground designated for such function)	103.20	2.24
Grand Total	**4616.97**	**100.00**

The table shows three dominant types of land use, which are agriculture fields, empty space and riparian zones. In terms of typology the dominant spaces are also clearly seen in Figure 9.2.

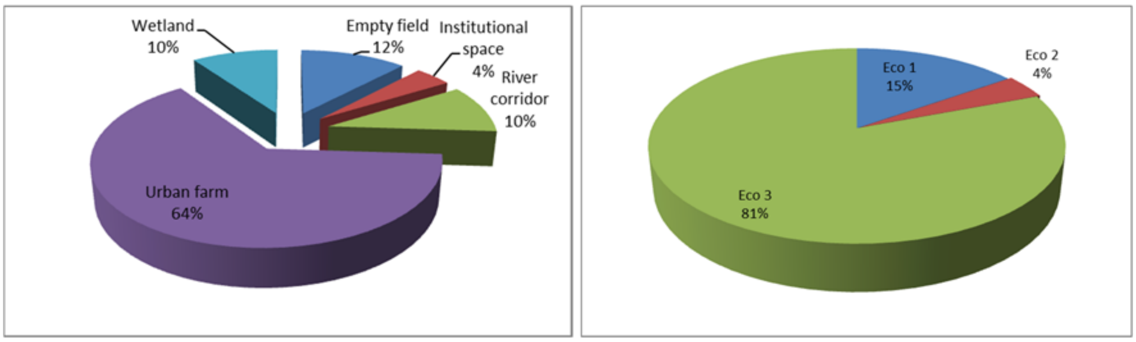

Figure 9.2. Proportion of space typology and class of spaces in the final preferred spaces

The space typology has become the basic space classification for most of the previous analysis, whereas the land-use most reflects the more detailed functional breakdown of some typologies. Table 9.1 presents a summary of various land uses according to government description in various maps. Some land uses merge into the same typology group following similarities in characteristics, value and content. The riparian zones mostly consist of wetland and river corridor, whereas institutional spaces are distributed between several land uses, such as school yard, church or mosque yard, campus ground and a significant area of urban forest, which is the campus ground of Hasanuddin University.

The description of land use is necessary to address more specific functions whereas the more general typology was designated to simplify data collection and make the methodological approach more practical.

9.2. Linking up the spaces

Greenways, green networks and ecological networks are derived from the idea of linking up spaces either into a network or just as a continuous linear feature leading to natural areas outside the urban area. The network is formed by connecting features through branching or circuit networks and the performance or feasibility of this network can be assessed through node and connectivity analysis (J. Linehan et al., 1995).

There have been a number of studies on ecological networks and greenways in urban areas. Some have analysed current urban ecological and green networks and greenways in terms of their feasibility and performance (Cook, 2002), others have assessed viable green spaces in a city in order to discover patterns and connections for making a network (Uy & Nakagoshi, 2007), and others have looked at the theories behind green spaces in urban areas (Maria Ignatieva, Meurk, Roon, Simcock, & Stewart, 2008).

For this study, it is important to re-emphasize the analysis starts from the assumption that at present no such network of ecological or green spots is available in Makassar. This is simply because there is no available information in relation to these ideas. Even official documents have not expressed an intention to create any form of connection between the green and open spaces in the city. The government has information about the location of available green spaces but no information on topics such as biodiversity, naturalness, and connectivity which would enable their assessment for potential as ecological or viable green spots, all features thought necessary for the existence of such a network (Cook, 2002).

Therefore, departing from this lack of knowledge, it is first important to understand all the existing spaces in terms of type and assess their potential for inclusion into any form of network, either of ecological or urban habitat value. When spaces have been identified for their significance, it will then be possible to see whether green spaces throughout the city of Makassar can somehow be utilized and connected in the form of a network. The feasibility of spaces for inclusion in such a network are mainly assessed by considering the score of the space in terms of plant biodiversity and other observed qualities in the field. The feasibility here contains different levels of preference according to the analysis of biodiversity and in-field characteristics.

The study in Makassar is aimed at producing any possible network that links spaces of certain qualities. This thesis, therefore, mainly describes the stages for identifying such potential spaces (see Chapter 8). In order to connect spaces in Makassar previous studies of ecological networks can also provide ideas about whether similar methods are applicable to the city. Applicability of a method refers to the availability of necessary data and information, the resources required, as well as the effectiveness in terms of the study coverage. Table 9.2 presents a selection of studies on ecological networks conducted in different places.

Table 9.2. Selected previous studies of ecological networks

No	Name of Study	Description of Study	Components of Observation and Analysis	Type and Tools of Analysis	Products/Results
1	Connectivity analysis of urban green spaces in Coquitlan British Columbia, Canada (Rudd, Vala, & Schaefer, 2002)	Examines the connections between green spaces and analyses the best potential network to link them	Patches are defined as nodes which refer to green spaces, consisting of: - mother nodes: large green spaces that have a greater influence - satellite nodes: smaller green spaces that act as peripheral habitat Minimum nodal area selected for indicator species was 0.5 ha which was arbitrarily chosen as a hypothetical minimum area requirement. It was chosen to encompass a wider range of species	Gravity model (J. Linehan et al., 1995) to evaluate the level of interaction between the nodes. Consisting of: - Nodal analysis - Connectivity analysis Network importance and significance was evaluated with Gamma, Beta and Cost Ratio Indices. Using MATLAB (Version 5.2.0.3084 Mathworks Inc)	Network options and scenario tested with both branching and circuit network model/approach Best network criteria: connecting most nodes and higher degree of connectivity
2	Analysing urban green space pattern and eco-network in Hanoi, Vietnam (Uy & Nakagoshi, 2007)	Quantification of landscape patterns and ecological processes to identify green space changes. Graph theory was the applied to find any networking as a biodiversity conservation strategy	This study reclassified urban green spaces, then used definitions of landscape metrics from Mc Garigal et.al (2002) to study the synoptic characteristics for obtaining general information on urban green space patterns. Nodes for gravity model refer to green area of more than 10 ha which was considered to encompass a wider range of species.	Gradient analysis to study urbanization process (changes in green spaces); graph theory with gravity model (J. Linehan et al., 1995) to analyse green nodes, their interaction and links used to connect these nodes. In addition to Gamma, Beta and Cost Ratio, this study also analysed networks through their circuitry and connectivity. Using FRAGSTAT 3.3.	The Synoptic characteristics of urban green spaces along with gradient analysis of landscape level metrics which show level of urbanization and the possible driving force. Network analysis produced a good network that satisfies all criteria (Beta, Gamma, and Cost Ratio)

Table 9.2. Continued

3	Landscape structure indices for assessing urban ecological networks-Phoenix, Arizona (Cook, 2002)	Viability of an urban ecological network was assessed by analysing landscape structures.	Patches and corridors of both natural and cultural value were assessed then compared to optimal plan to understand the level of change to be expected	Three principle analyses were used: 1. Patch content analysis 2. Corridors content analysis 3. Network structure analysis Content analysis consisted of size and type; vegetative structure and diversity; context; and naturalness index. Networks structure analysis consisted of mesh density/ naturalness index; matrix utility index; and circuitry and connectivity	Knowledge of the ecological network performance relative to the ecological system in the region
4	A case study of urban ecological networks and a sustainable city in Tehran's metropolitan area (Aminzadeh & Khansefid, 2010)	This study assessed the current situation and analysed the natural and built elements of an ecological network	Patch-corridor-matrix model with the layers of patches (natural and built, including open and green spaces) and corridors (with hydrological networks as the main ecological corridors and roads, highway and streets)	This is a conceptual framework-based study. Layers of patches and corridors were merged to obtain the overall ecological structure of the city showing all effective features of the city.	The overlaid map produced patterns of networks, also showing natural and built elements of the city's ecological network. The map also showed the main constraints for the ecological context which makes proposing strategies for improvement possible

There are other studies, apart from those in Table 9.2 studies, which focus on assessing individual green and ecological patches and nodes for creation of larger connectivity and circuitry between these spaces within a region. One assesses ecological connectivity at regional scale (Marulli & Mallarach, 2005), another study specifically estimates the connectivity of habitat patches (Nikolakaki, 2004), and one takes the habitats of certain key species as the main focus (Hepcan et al., 2009).

Connectivity refers to landscape function related to the process of movements, whereas connectedness is related to structural links between elements of landscape spatial structures, hence functioning as the means of species movement (Rob H. G. Jongman et al., 2004).

All the studies in Table 9.2 are also concerned with classification of spaces in various ways before starting any network analysis. Nevertheless, most have used established classifications of space. Uy & Nakagoshi (2007) did reclassify government spaces, but did not perform any assessment of these prior to this reclassification.

There are several common themes among the studies that differ from the Makassar study. Firstly, all the considered spaces, either referred to as nodes or patches, were chosen for specific reasons. Studies by Rudd, Vala, & Schaefer (2002) and Uy & Nakagoshi (2007) considered the size of the space, as this is believed to indicate the presence of wider animal species. This could be applied to the Makassar study, although the consideration here is based on plant species, as plants are the basic habitat feature. Two studies (Aminzadeh & Khansefid, 2010; Cook, 2002) considered spaces which are believed to be part of an established ecological network or possess the quality to be such. Therefore the types of spaces used in these studies appeared simpler and less diverse than those of the Makassar study.

Overall in the studies, spaces are defined as green spaces (Rudd et al., 2002; Uy & Nakagoshi, 2007) or patches of a natural or built area (Aminzadeh & Khansefid, 2010; Cook, 2002), whereas the Makassar study has a typology of 16 patches and corridors. In terms of proposing a network, all the studies only assessed patches and proposed a network by looking at the most available connecting corridors or stepping stones. The Makassar study assessed both patches and corridors, although the method for assessing biodiversity was not differentiated between them, which could be a weakness of this study.

In addition, all spaces included and assessed in the four studies (Table 9.2.) are stated to have ecological values for an ecological network. On the other hand, for the Makassar study even when spaces are procured through the three stages considered to have the most potential, not all are feasible ecological spots. Selecting only the best spaces (Eco#1) according to the class of space as presented in Table 8.11 (Chapter 8) would bridge this difference, and would reduce the number of spaces available in the city which could be recommended for improvement. The last difference relates to the scope of each study. Apart from the study in Tehran, the detail assessment of the other three studies only covered certain regions of the urban area. The Tehran study did cover the whole city, yet the proposed network was the result of patch and corridor correlations without assessing all patches individually.

Table 9.3 summarizes comparison of the Makassar study and the other ecological network studies with respect to the attributes involved prior to a network analysis

Table 9.3. Attributes of Makassar study compared to other studies

No	Attribute of study for network analysis	Makassar Study	Other Studies (Table 9.2.)
1	Initial assumption	No network of any form exists	Network is established, or is likely to exist
2	Spaces for analysis	Spaces from a developed typology considering class of space and birds as target species	Existing defined spaces, which might be redefined or classified as natural or built (cultural)
3	Space size determinant	Size filter applied during space analysis by considering plants for habitat; final preferred spaces might include small patch	Sizes which are considered to accommodate wider animal species, or size does not matter for the established green spaces.
4	Space ecological quality	Diverse, as the preferred spaces considered not only biodiversity	Spaces assessed are all assumed to be ecologically worthwhile.
5	Area of study	The whole city	Part of the city, or the whole city but without detailed individual patch (node) analysis
6	Number of patches analysed	847 patches and corridors	Studies with detail individual node analysis have 33, 54 and 70 patches
7	Main tools	GIS, fieldwork	GIS with additional extension for landscape analysis such as FRAGSTAT and MATLAB

As seen in Table 9.3, the Makassar study has different aspects from the previous studies. Some appear slight, such as the definitions of patches for their inclusion and determination of size standard, but these differences might also be significant. It is also important to note that the other studies were generally performed in areas where an ecological network had been presumed to be established, and the analysis was, therefore, mainly intended to be one of network performance.

Addressing the scope of the study area and the implied level of node and patch analysis, it seems further simplification of spaces in Makassar is required in order to perform a similar analysis to the other studies. With the great number of patches in Makassar, the node interaction would be too complicated and the possible networks generated would be very complicated if not chaotic. One way of simplifying spaces further is by sticking to a specific patch size which would accommodate wider animal species. However, there is a limitation in doing this, because the fieldwork confirmed that despite being high scoring in terms of vascular plant biodiversity, most spaces in Makassar are still not immediately suitable for species habitat. Moreover, large patches in the city are dominated by cultural activities, such as agricultural fields and fish ponds. In other words, given the current state of spaces in Makassar, it is pointless to set up a certain size for animal habitat where the available patches could not support this. Nevertheless, patch size was considered in determining class of space (see Section 8.3).

Simplification would result in fewer spaces being available for the city to consider in its spatial planning. However, this study has provided classes of space (see Table 8.11) which are available to use should a further network analysis be based only on a certain quality of space as a simplification measure.

9.3. What is the most appropriate term?

In terms of quality of space, the analysis and fieldwork has led to an understanding of spaces in and around the city of Makassar. The critical question then emerges as to whether all the spaces and corridor lines in the city possess the quality to serve as patches and corridors for an ecological network. As said before, this study does not aim to investigate or to test an existing ecological network, but rather to examine the possibility of creating one. Therefore, approaches for investigating the performance of an ecological network (Cook, 2002; Hepcan et al., 2009) would not be appropriate. However, the inventory mapping of spaces makes this study similar to that of Uy & Nakagoshi (2007), thus it might be possible to analyse the ecological network further using their tools and resources. This study, by assessing available patches and corridors of both infrastructure and hydrological systems, is like the study by (Aminzadeh & Khansefid, 2010), although the Makassar study elaborated the spaces to include more diverse land uses.

This study performed assessment on the two main elements of patches and corridors. The method used was a rapid method for providing general information regarding biodiversity, and was not designed to give detailed results in terms of the ecological quality of a patch. Consequently, this study did not have sufficient resources and hence could not measure the quality of a space prior to its designation as an ecological spot nor investigate the viability of an ecological network. Nevertheless, visual observations were made during the fieldwork focusing on the important aspects that are necessary for a patch to be able to function as part of an ecological network. These aspects are set out below.

1. Spaces which are to be considered main patches in a viable ecological network should be the core areas which are usually protected by buffers. These core areas are commonly safeguarded and conserved by establishment of protected areas (R. Jongman & Pungetti, 2004), and in many cases they could be considered as Key Biodiversity Areas (KBA) (Hepcan et al., 2009). These types of patch do not exist in the main city of Makassar.
2. An ecological network should be constructed by the linkage of natural patches, with this being supported by cultural patches with an adequate level of naturalness as well as natural corridors. Referring to the definition of natural spaces (Box & Harrison, 1993; Michelot, Trinquelle, & Dutruge, 2004), unfortunately in Makassar very few identified spaces fulfil the requirement to be classified as ‘natural’. Spaces once thought to be natural did not have the quality of natural patches in the field.
3. All spaces suffer significant human impact and intensive land use, which result in possible pollution. There is potential disturbance of the possible future habitat. Some patches, despite being large in size are also poorly vegetated, hence scored low in biodiversity. Countries, such as Germany, Greece, Portugal and France note the importance of having areas with limited and controlled human activities and influences, as implied in the way these countries define a national park (R. Jongman & Pungetti, 2004, p. 25).

4. All existing corridors barely support measured biodiversity. Most corridors, especially road corridors, are constituted by either a single row of vegetation or narrow corridor. These corridors are too narrow to create the internal areas necessary to have a corridor that is ecologically functional to serve as habitat, filter, conduit, ecological source and sink (Richard T. T. Forman, 1995).
5. There are significant exotic and introduced plant species in Makassar. Although the survey did not specifically measure the percentage of exotic species in the surveyed location, their existence was visually dominant. Even in some spaces which scored high, the vascular plants constitute many exotic species such as ornamental and introduced plants. This is particularly observable in some institutional spaces such as government offices, schools and campus grounds. Apart from the plant species, the vegetation layout is far from natural as the planting has been designed in accordance with the site planning. An ecological network will be highly valued according to a biodiversity represented by native species (Cook, 2002), and as profiled by plant signatures (Maria Ignatieva et al., 2008), which are best as natives.

Acknowledging these facts and given the conditions of Makassar, an ecological network would not be possible in the present conditions of Makassar. This conclusion is based on considering aspects such as quality of patches, absence of native and natural content, human disturbances, and lack of viable functioning features for corridors. Nevertheless, remnants of Nypa palm along the main river, despite experiencing severe fragmentation, could be good starting point for preservation and conservation measures for their improvement.

The initiative for improving the river corridors could be part of significant efforts to improve patches in the city in order to increase the ecological value of the spots. Meanwhile, whatever the existing spaces, these need to be preserved and promoted. One way of preserving the value of a space is by including it in a network. Therefore despite the unlikely conditions for an ecological network, it is still worth trying to connect spaces in this city as part of a plan to preserve and improve them. Creating a network of spaces would be valuable for the city whatever term is used to describe it. It might be green network, a spaces network, or preferred spaces network, and this would not really matter at this point. What important is to link up the spaces into one connected system.

To sum up, previous network analysis studies have suggested using more complicated methods than undertaken in this study. They involved performance analysis of individual patches and nodes, and the interaction between patches and the index of connectivity or circuitry. For such an analysis, additional data and tools are required. The method proposed by Cook, for example, being the most complicated one, apart from vegetative structure also analyses patch context as part of the network analysis. Additional data required for such a purpose is the intensity value of land use. Other relevant aspects which are not particularly addressed by this study are human impact, which affects the level of indigenous plants and the naturalness index (Cook, 2002), and soil compaction. Moreover, in order to perform an analysis including all these aspects, additional GIS tools are required, such as FRAGSTAT 3.3, which unfortunately were not available for this study.

However, the map of spaces resulting from the Makassar study could be assessed for a network in the way Aminzadeh & Khansefid (2010) did. Later, it would be possible to retrieve more maps from this Makassar study which could be further analysed for more accurate quantitative results related to the network analysis, on the presumption that Makassar spaces have the qualities to be linked in the form of an ecological or green network. This is an area for further research.

9.4. A network for the city

Even without specific tools to analyse the network, the map in Figure 9.3 provides a clear illustration of what patches are available and how separate small patches are dispersed, thus revealing the possibility for linking them. From the map, some large patches are evident and their distances apart are very short, creating the effect of larger patches as a combination of several proximate patches.

For corridors, as has been observed before for Makassar's main river corridors, the layout of several small patches seem to line up to form a corridor. This could be a significant corridor, especially when improvement is made to ensure their continuity. It is also important to remember the role of roads and spaces between houses, as despite scoring low in biodiversity, these can support other most preferred high scoring spaces.

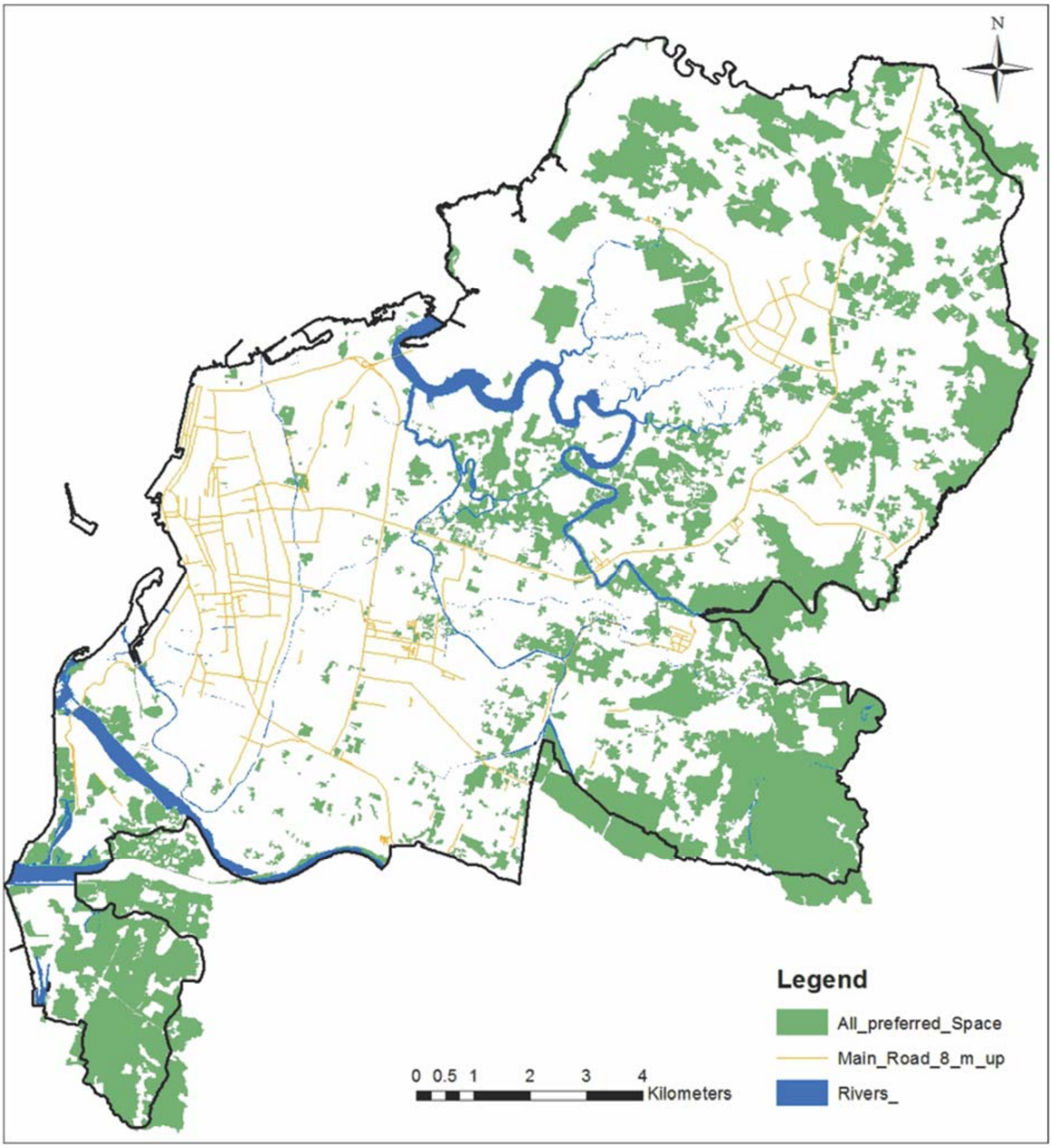

Figure 9.3. Spaces in Makassar considered to have potential to be linked into network/s

Adapting the approach of the study by Aminzadeh & Khansefid (2010), spaces in Figure 9.3 can be represented using the other definitions of nodes and links as shown in Figure 9.4.

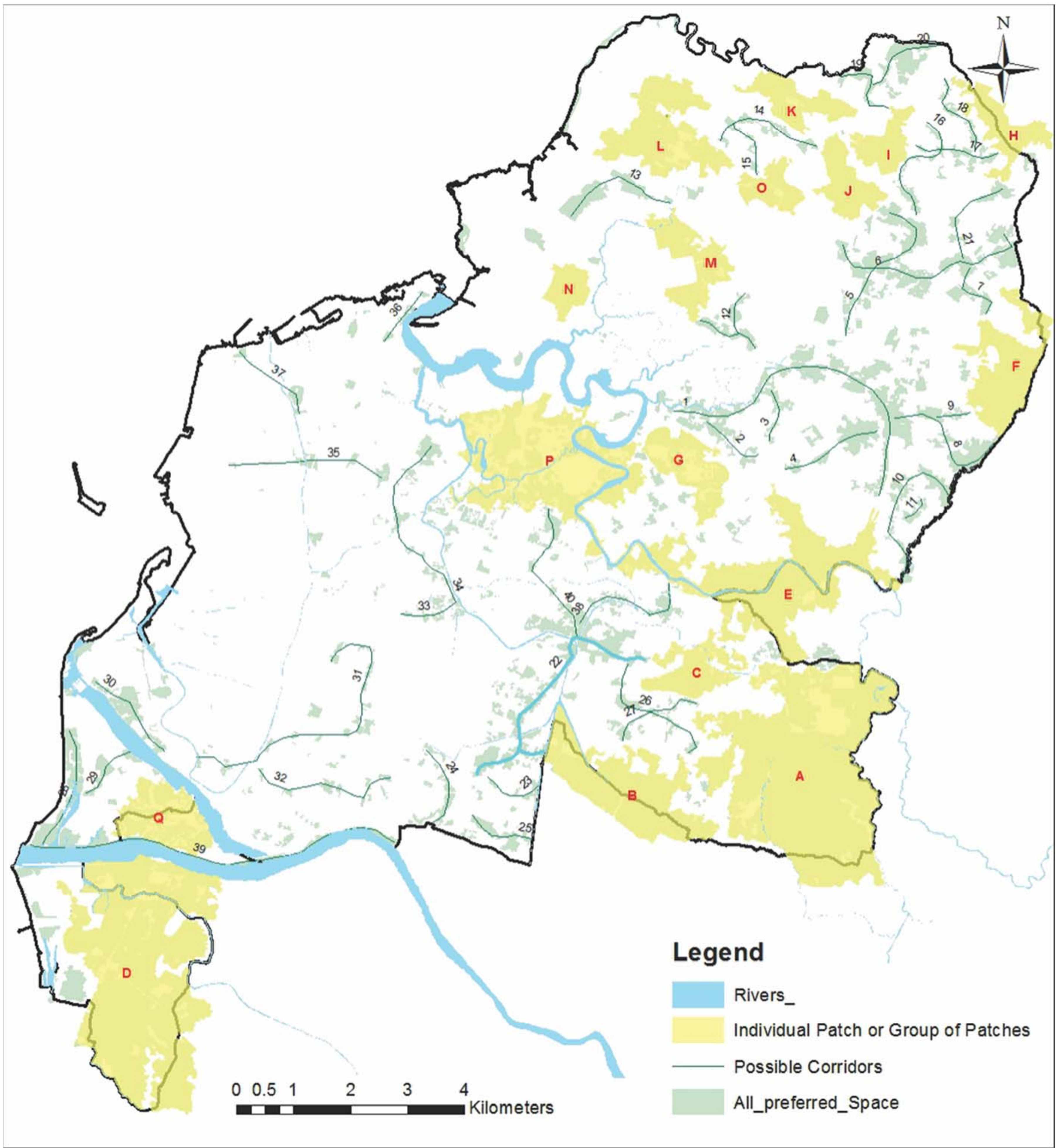

Figure 9.4. Main patches and possible corridors for connecting them
(alphabetical patch codes are explained in Table 9.4. and numerical in Table 9.5.)

Based on the preferred spaces available in Makassar which have been grouped into a number of main patches based on their proximity, and along with possible links through lines of patches as stepping stones (Figure 9.4), it is now possible to propose a network. From this figure, the most probable network in Makassar is the branching type. The absence of spaces in the west part of the city makes the possibility for a circuit network for the whole city currently impossible, although it could be a future possibility through creating a green coastal area, such as by establishing mangroves along the coast. Concerning the physical appearance of patches and corridors, among all of the spaces, there are several patches or groups of patch that could be considered as a node or main patch. There are 17 of these main patches that look to be significant in size, either as an individual patch or because of the close proximity of several spaces. Table 9.4 describes the patches as individual or group, which according to their position could be considered as a main node patch for a possible network.

Table 9.4. General description of the possible main node patches in Makassar

Patch Code	Contents and Physical Conditions	Area (ha)
A	Mostly paddy field	864.26
B	Paddy field and mixed crops	282.67
C	Paddy field, mixed crops and wetland	104.63
D	Mostly paddy field with swamp separating these from the river	797.10
E	Combination of paddy field with Nypa palm as remnant of natural river corridor	438.52
F	Paddy field and empty field	179.44
G	Campus ground announced as official urban forest	123.93
H	Paddy field	95.58
I	Paddy field and farm with empty field	67.24
J	Farm of mixed crops	84.89
K	Combination of farm and empty field	88.77
L	Paddy field and farm	213.03
M	Farm field	117.63
N	Farm field	51.68
O	Farm field with empty field	60.55
P	Fragmented patches of natural river corridor with fishponds in between	475.10
Q	Group of paddy and farm fields severely fragmented by settlement	143.16

From Figure 9.4 and Table 9.4, it is obvious most spaces are cultural fields in the form of urban farms of various types. Therefore according to the land use, land status (ownership) and current conditions, these spaces, even though they are the main node patches in this network analysis, are still not in the most ideal condition and are potentially threatened by further fragmentation. However the inclusion of them in a network would hopefully make these spaces more appreciated through local government recognition of their value to the city, thus preventing further encroachment of built environment on farmland.

The most viable node patches are by the river. In fact both during observation and biodiversity assumption based on the assessment of spaces which represent them, they are considered to be corridors formed by dispersed fragmented natural corridors. However, for analysis of a possible network, these groups of fragmented small patches could serve as a patch.

According to the existence of linear features and dispersed small patches, it is also possible to propose corridors in form of stepping stones. Figure 9.4 shows possible connections of patches, numbered according to the general description in Table 9.5.

According to USDA recommended standards, even large mammals ideally need corridors formed by stepping stones, separated by a maximum distance of 110 metres (Bentrup, 2008). However, the patches in Makassar which might form stepping-stone corridors, are far from being part of an acceptable ecological corridor because of their distance apart and intrinsic quality. However for birds, the distances are greater and small patches with trees could serve as a transit conduit for their movement. Therefore, this study considers distance apart by regarding their expected function as being mainly stepping stones for birds. Patches are considered close if the distance between them is less than 150m; apart when the distance is between 150 and 300m, and far apart when the distance is more than 300 m.

Table 9.5. General description of possible Makassar corridors in the form of stepping stones

Corridor Code	Type	Physical content based on land use of the patches	Distance
1	Stepping stones	Paddy field, mixed crop farm field, empty field, Nypa palm	close
2	Stepping stones	Paddy field, Nypa palm	apart
3	Stepping stones	Empty field, farm field	close
4	Stepping stones	Farm, empty field	apart
5	Stepping stones	Institutional park, empty field, paddy and farm field	close
6	Stepping stones	Paddy field and farm, empty field	close
7	Stepping stones	Paddy and farm field, empty space	close
8	Stepping stones	Paddy field, empty field, farm	apart
9	Stepping stones	Farm	close
10	Stepping stones	Paddy field, farm, empty field, nypa palm, swamp	close
11	Stepping stones	Farm field	close
12	Stepping stones	Institutional park, paddy and farm field	close
13	Stepping stones	Empty field and wetland	apart
14	Stepping stones	Farm field and empty field	apart
15	Stepping stones	Farm field and empty field	apart
16	Stepping stones	Institutional and residential yard, empty field, farm field and green space	close
17	Stepping stones	Empty field, farm field and green space	close
18	Stepping stones	Empty field, farm field and green space	close
19	Continuous patches	Paddy and farm field, green space	-
20	Continuous patches	Paddy and farm field, empty field and green space	-
21	Stepping stones	Paddy and farm field, empty field	apart
22	Stepping stones	Paddy and farm field, empty field, marshland	close
23	Stepping stones	Empty field and marshland	close
24	Stepping stones	Empty field and marshland	close
25	Stepping stones, nearly continuous	Paddy field, marshland	close
26	Stepping stones	Farm field and empty field	apart
27	Stepping stones	Farm field and empty field	apart
28	Continuous patches	Farm field, empty field, marshland	-
29	Stepping stones	Farm field and marshland	apart
30	Stepping stones	Empty field and marshland	close
31	Stepping stones	Empty field and institutional green space	far apart
32	Stepping stones	Empty field and marshland	far apart
33	Stepping stones	Empty field and marshland around residential areas	apart
34	Stepping stones	Empty field, wetland and marshland around residential areas	apart

Table 9.5. Continued

35	Stepping stones	Institutional empty field	apart
36	Stepping stones	Swamp, empty field and Nypa palm	apart
37	Stepping stones	Institutional empty field/ green space	apart
38	Continuous patches	Paddy field and natural river corridor in form of Nypa palm	-
39	Continuous patches	Empty field, farm field	-
40	Stepping stones	Institutional park and empty field, paddy field, Nypa palm	apart

Table 9.5 presents the spaces which could serve as stepping stones in the preferred spaces network, and their different states and conditions. Some corridors are formed by well-established stepping stones regarding their continuity and distance between patches, while some are formed by fragile connections because of the distance between them and their condition. These will need improvement to be acceptable stepping stones.

Continuous lines of roads, streams and rivers are also possible corridors. However, those included in Figure 9.4 are scattered along the main river as these are the only ones identified as having significant space to be corridors. Roads and streams on the other hand could also be seen as potential corridors even though they are not among the preferred spaces obtained through the analysis (Chapter 8). However, it is important to understand that all spaces, either patches or corridors, analysed for a possible network are not in a condition to be viable ecological or habitat spots. Therefore whatever might be established in the city is not an ecological network. These are the spaces considered to have the most potential but which need improvement to become ecologically important. Since the preferred spaces are all non-built spaces, either densely vegetated or just empty grassed fields, it might be more appropriate to use the term ‘green network’ since this is a known term. Otherwise the description might be ‘preferred spaces network’.

When proposing connection of those preferred spaces, selection of corridors would need to consider and analyse the potential of and restrictions on each line. The ones with higher potential and fewer risks should be given priority. Again with the absence of a performance analysis of each individual patch and an interaction analysis for them due to the limitation of resources, this study proposes the layout of the available and preferred main patches and corridors as the base for further network analysis using whatever tools are possible and become available.

9.5. The bigger picture: the greater urban region of Makassar and adjoining regencies

Among the many reasons for linking spaces together, targeting specific species drives such initiatives, as shown in how corridors can be set up as supporting patches for a specific goal such as attracting forest birds to the urban area (see Section 10.2.5). This can lead to the introduction and management of spaces to accommodate this.

Having assessed Makassar as a place where urbanization is at a very high level, it is important to acknowledge the inclusion of adjoining areas in order to create a more viable macro green environment within a green or ecological network system. Plenty of spaces might still be available in Makassar, but quality of space in terms of ecology is the issue. Such spaces could be good temporary stop over points for species like birds where quality habitats are available within reachable range, or where there is available functional or behavioural connectivity.

Although there has been no specific study to determine the level of urbanization in Makassar, as has been done in Jakarta, Bangkok and Manila (Murakami et al., 2005), by looking at its development and growth pattern, it seems Makassar is also experiencing signs of sub-urbanization, where concentration of population density is no longer in the inner city but has spread to the urban fringe. This has led to the need for integration of Makassar city and the surrounding regions within one development plan.

Looking at the study location context, within the greater urban region of Makassar and the three adjoining regencies (Mamminasata) there are two national parks: Bantimurung National park in Maros and Komara wildlife reserve in Takalar. These two reserves are legally protected through decrees of the Forestry Minister (Presidential decree, 2011) and can be considered as the Key Biodiversity Areas (KBA) for this region. Including these two reserves as target patches supported by other patches of forests around the area would drive the establishment of connections and linkages by utilizing spaces wherever possible.

Bantimurung national park is an area of 43,000 ha, especially designated as a reserve area for butterflies with the existence of waterfalls and streams which are favourite recreational attractions. Most habitat areas are excluded from human disturbance.

Figure 9.5. Bantimurung National Park in Regency of Maros, about 40km from Makassar.
(Source: Khalied (2011); Jantan Blogspot (2012))

Komara wildlife reserves in Takalar originated from 3,000 ha of protected forests which were increased to an area of 4,610 ha, embedded with a hunting park (Ministry of Forestry, 2013). With the latter decree the status was updated and the area divided into 1,633 ha of hunting ground and 2,251 ha of limited wood forest and wildlife reserves (Presidential decree, 2011).

Figure 9.6. Komara wildlife reserve (left) and hunting ground (right) in Takalar, about 90km from Makassar.
(Source: Redgum (2012); Natural Resource Conservation Board (2013)

Regarding these two official natural reserves as the main patch and ecological resource in a network for the whole greater area, it would be possible to consider the available features and spaces which could serve as stepping stones or even continuous corridors as well as transit patches and spots.

The matrix of the rural landscape appears to provide a greater chance of establishing a feasible network of ecology quality. Looking at the map in Figure 9.8, the main city of Makassar and the natural reserves can be connected through several features. Agricultural fields, which have potential according to assessment of urban farms in the main city, are continuous in the area. Having said that, farms in rural areas are probably better and more natural in biodiversity terms and are also more various than in the city. The existence of forest patches also provides more options. Even rural settlements are much greener than those in the urban landscape (Figure 9.7.).

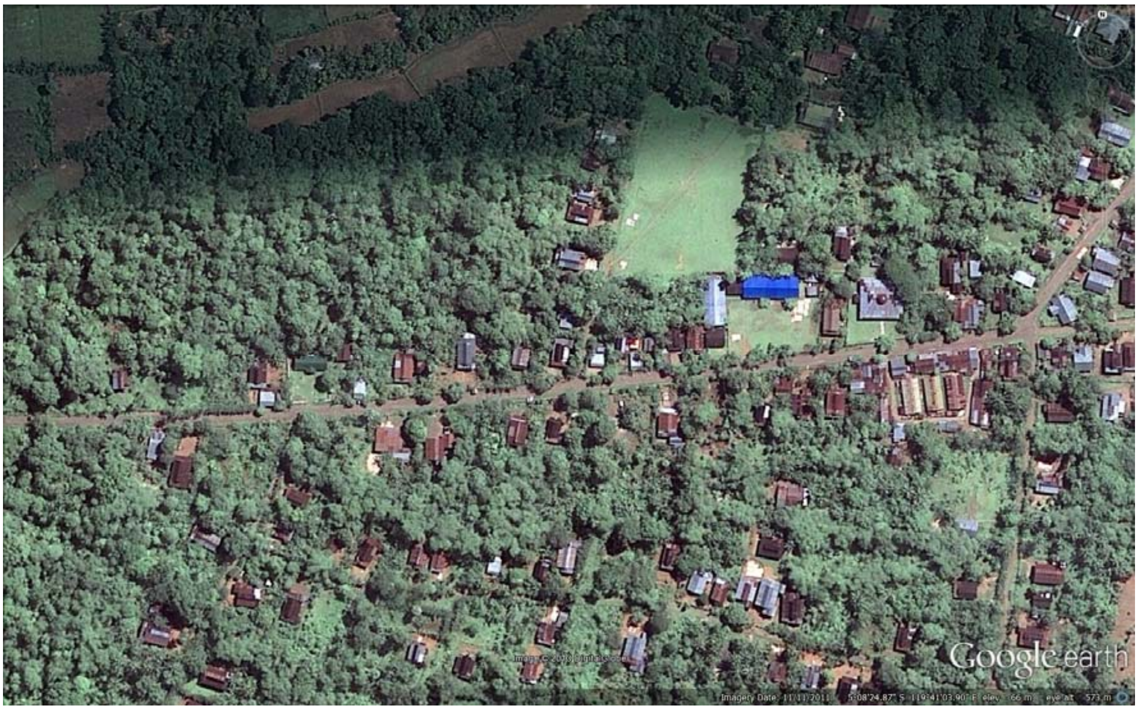

Figure 9.7. Dense green areas that dominate rural settlements along country roads have potential to become green road corridors (Source: Google earth, 2012)

Figure 9.8 shows the general land-use of the greater area. Land use in Mamminasata is dominated by agriculture fields. The most significant coverage is paddy fields, with some mixed-crop plantations and farms located around houses and settlements. However there are large areas of both protected and productive forests in the fringes of the area. These protected forests could also serve as important patches and sources in support of the national park. As farms are persistently connected throughout the area, they are important features for creation of a network. Farms in these rural areas could be improved following certain methods (See Section 10.2.1.) because the absence of built structures creates opportunities for planting non-agricultural commodities. Rivers definitely have an important role as connecting features especially if their corridors are maintained in a natural state or improved. Streams also lead to both reserves.

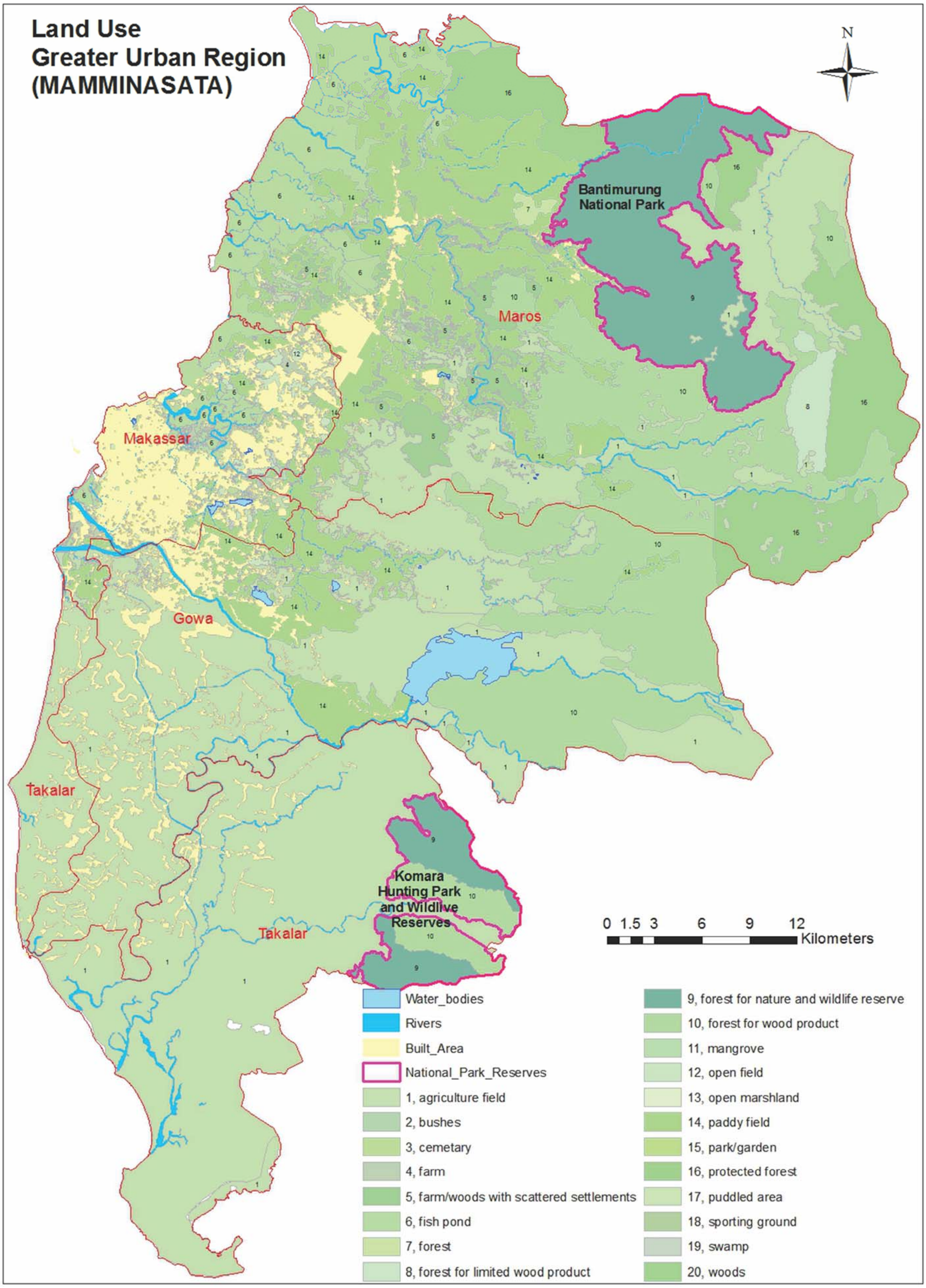

Figure 9.8. General land use of Mamminasata greater urban region

The landscapes between Makassar and the two national parks and reserves are dominated by agriculture. However, that between the main city and Bantimurung National Park is more varied than that between the city and the Komara Reserves. The possible connections from the main city to these two reserves are illustrated in Figure 9.10.

For the area between the main city and Bantimurung, patches of a combination of mixed crop farms and woods with scattered settlements seem to be significant. The large productive forest could act as an ecological habitat as the cycle of years between planting and harvest is large. More concentrated settlements normally run along either streams or roads or even both. These lines of settlement have dense green coverage around them, suggesting that corridors around or within properties are also important opportunities for optimization.

From Figure 9.10, apart from the two natural reserves in the area, protected forest (16) and forest for limited wood production (8) could also become important ecological patches. The continuous spread of productive forest (10) would provide viable connections to the farms with their settlements (5). Their combination creates strong connections across the area. Backed by agricultural fields and fish ponds, these combinations should be able to be connected to the suggested green network in the main city of Makassar (22).

Figure 9.9. Strong and feasible corridors via productive forest (left) and farm/woods with scattered settlements (right) (Source: Google earth, 2012)

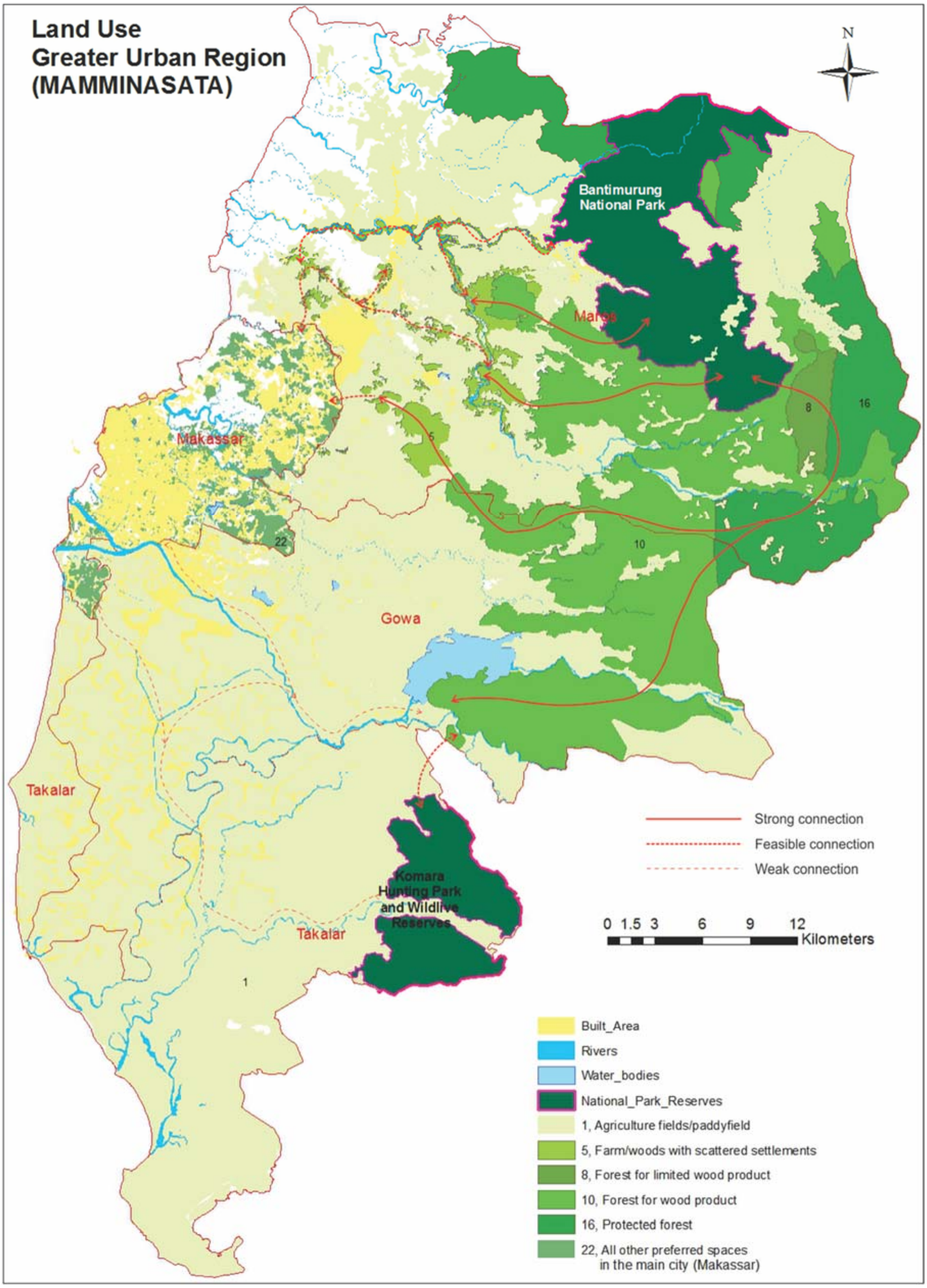

Figure 9.10. Possible network connections in the greater urban region

Non-paddy field patches connecting Makassar with the Komara wildlife reserves would be farms around settlements along roads and rivers. However these settlement corridors are not as green as those leading to Bantimurung National Park. Therefore for this Takalar matrix, paddy fields (1) are the most significant available connecting feature. However, due to the openness and the lack of diverse vegetation structure within these fields, the connection would be considered weak.

Figure 9.11. Lines of rural settlements along rivers and roads with their dense greenery make good corridors between the main city and Bantimurung National Park
(Source: Google earth, 2012)

Connection between both reserves could be achieved because of the existence of a large patch of forest spreading from Bantimurung down to Takalar. Improved agricultural fields would provide further connection to the border of the Komara wildlife reserves.

Figure 9.12. Typical landscape matrices between Makassar and Komara Wildlife Reserves showing poor green coverage (Source: Google earth, 2012)

Comparing the landscape matrices of Figure 9.11 and Figure 9.12, it is clear that the landscape between the city and Bantimurung National Park has more varied land use. Although dominated by agricultural fields, there are significant variations among the farms from paddy fields to seasonal and mixed crops. Patches of woods and productive forests are also significant parts of the landscape, while the matrix between the city and Komara reserves mainly consists of paddy fields. The more varied structure gives more possibilities for improving the landscape ecological quality.

Although these rural areas are much greener and have more potential for establishing a green or ecological network compared to the more urbanized areas of the main city of Makassar, it is still important to anticipate possible development which could decrease the quality of their nature. Things that could happen are forest clearance for new homes along with population increase, forest encroachment for opening new agricultural fields, and loss of trees as well as construction of houses along river corridors where no buffering zone has been created and legally protected. These are the issues to be addressed and managed before a viable green or ecological network can be well established.

Connecting Makassar with the two more 'natural regencies' in this way can also be justified in terms of providing and preserving connectivity between landscape sites, given the need for hosting native and migrating species from areas disturbed by development (Rob H. G. Jongman et al., 2004).

9.6. Summary

This chapter present analysis of how a network of green spaces could be created for Makassar. All preferred patches were further grouped into main patches and patches for stepping stone corridors. The main idea is to see possible ways of connecting the main patches with the available stepping stones within one connected system. Learning from other studies on connectivity of spaces, it appears that to see the connectivity in a more quantitative way further analysis involving additional extension of the mapping software is needed, something that could not be undertaken in this study. However, from the map of preferred spaces, connectivity of the main patches is possible given the scattered spaces are utilized properly as stepping stones to compensate for the absence of road corridors. This chapter therefore did not suggest a final model of a green spaces network. This is because the options for connection would be dependent on improvement of the 'stepping stones' as well as the main patches. However, at the bigger scale and looking at land use types and the character of spaces outside the main city, there is a better opportunity for connection. This would be achieved by linking up patches inside and outside the main city into more natural corridors that link to the national parks located to the north and south of the greater urban region. Maps of these possible networks for both the main city and greater urban region serve as basis for considering the possible next steps to achieve a viable network of green spaces.

Chapter 10

Further Considerations

This chapter first looks at the effect of the identified preferred spaces and the possibility for a green space network for Makassar on the relative provision of green space for its citizens. Given all potential spaces can be optimized, not only will creating a network provide more options for developing the city in a green direction but it could also improve the performance of the city in meeting green space standards and requirements. However, in order to optimize the available spaces they will need to be both maintained and improved. Therefore, the second part of this chapter also proposes possible improvements for spaces in Makassar that have the potential to be part of a green space network. Suggestions for improvement come from applications and studies elsewhere, including other regions in Indonesia.

10.1. Green spaces and demographic implications in Makassar

In order to comply with regulation at national level, the local authority of Makassar needs to recognize the importance of having knowledge about available open and green spaces in the city. With regard to the official national standard, this city should ideally have 20% of the total city area identified as 'urban open green space' (Ministry of Home Affairs, 2007). This 20% should be mainly public spaces or non-private spaces which are effectively managed by the authority. The Regulation of The Minister of Public works (2008) increased the requirement to 30% by incorporating 10% of the total available open green private spaces (Fajar-news, 2007).

This thesis first classified all spaces in the form of a typology (Chapter 5). The typology included investigating spaces with regard to their land-use by consulting government maps and through field observations. Chapter 5 also provided information regarding spaces acknowledged by the government as official spaces, thus denoting the possibility for their management and control. This study however, identified many more potentially available green spaces in the city, and hence produced a new map based on this (Figure 5.1).

10.1.1. Green space and demographics

Table 10.1 sets out all non-built spaces which have potential to be part of the open and green spaces in the city disregarding their land status and ownership. For most districts the proportion of green areas increases significantly when all available spaces are included. Identified spaces include private spaces of many types. According to the standard set by the Minister of Public Works (2008), when private grounds are included, the minimum proportion should be 30% in total. Four districts have spaces over one thousand hectares and in terms of the 30% proportion six districts exceed this.

Table 10.1. Potential open/green spaces in Makassar (including government recognized spaces plus study identified spaces) comprising all types of non-built spaces disregarding land status.

District	District Area	Potential open/Green spaces area (Ha)	Percentage of open/green spaces coverage
Biringkanaya	3,163.81	1,466.67	46.36%
Bontoala	147.58	7.46	5.06%
Makassar	251.06	8.42	3.36%
Mamajang	241.48	8.54	3.53%
Manggala	2,302.23	1,332.30	57.87%
Mariso	228.44	9.02	3.95%
Panakkukang	1,414.17	556.89	39.38%
Rappocini	1,207.32	158.62	13.14%
Tallo	903.40	309.94	34.31%
Tamalanrea	4,312.68	2,212.31	51.30%
Tamalate	2,627.40	1,114.84	42.43%
Ujung Pandang	282.64	14.56	5.15%
Ujung Tanah	189.70	8.04	4.24%
Wajo	204.11	0.96	0.47%
City Grand Total	**17,476.01**	**7,208.58**	**41.25%**

Source: Study inventory mapping

A study by Hidayansyah (2007) investigated green open space for the city of Makassar based on a Ministry of Public Works consideration, which prescribed 17.3m^2 of green space per person. This value was a result of adding up the needs for each person for various types of green spaces, such as neighbourhood park, sporting ground, and green corridors. The following analysis will show whether this prescribed value is achieved or not.

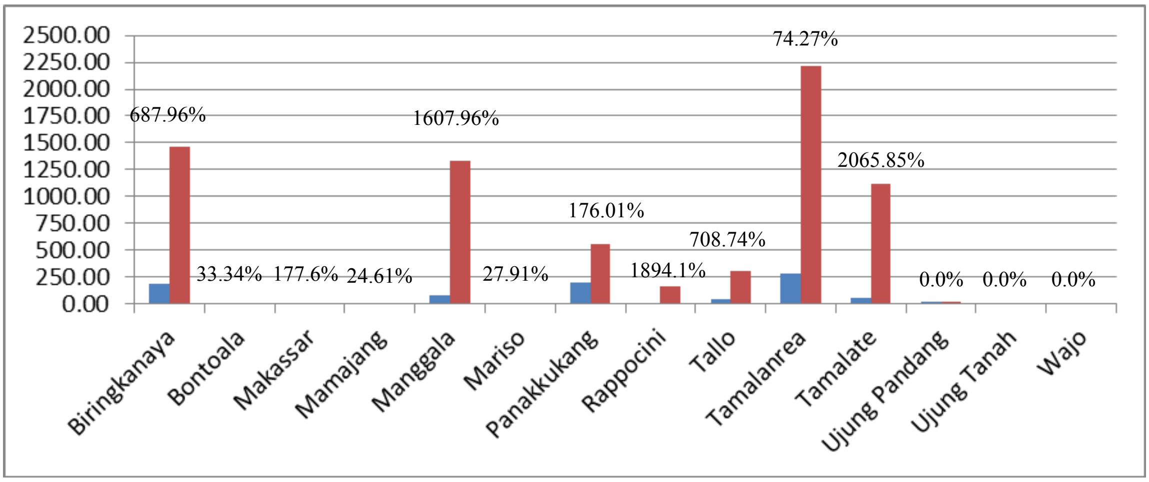

Figure 10.1. Area of open/green spaces based on government inventory (blue) (Table 4.4) and study inventory (red) (Table 10.1.), showing the percentage increase

On the other hand the percentage of open and green spaces in three districts (Ujung Pandang, Ujung Tanah and Wajo) remains the same, indicating that this study could not identify any more additional spaces. The total green areas and overall proportion are also boosted when all spaces whatever their land status are included. It is quite reasonable, however, to include spaces like agriculture fields and other forms of small scale private space as the Indonesian Ministry of Public Work recognize these as one type of open urban space (Directorate General of Spatial Planning, 2006). New questions then emerge as to how it might be possible to include non-government spaces, whether the owners of private spaces would agree to inclusion of these, and what kind of arrangements should be agreed between government and private owners. This, however, is beyond the scope of this study and is an area for further research.

Although the total area for the city fulfils the target percentage, the table shows that despite the inclusion of private space most districts are still deprived in terms of open and green areas. Whether or not this is a problem for people requires further evaluation along the lines of research into equally accessible green and open space for all residents in other countries (Anonymous, 2002; Handley, Pauleit, Slinn, Ling, & Lindley, 2006; Harrison et al., 1995). Again this is beyond the scope of this study, as the aim here is to look briefly at the match between the availability of open and green space, demographic conditions and recognized standards (Table 10.2.).

Table 10.2. Demographic aspects in relation to open/green spaces in Makassar

District	Values based on government area inventory of open/green space		Values based on study area inventory of open/green space	
	Open/green space ratio per capita (m^2/person)	**Open/green space ratio per household (m^2/household)**	**Open/green space ratio per capita (m^2/person)**	**Open/green space ratio per household (m^2/household)**
Biringkanaya	11.1	52.44	87.44	413.23
Bontoala	1.03	4.01	1.38	5.35
Makassar	0.37	1.93	1.03	5.35
Mamajang	1.16	4.25	1.45	5.30
Manggala	6.66	31.88	113.8	544.53
Mariso	1.26	5.34	1.61	6.83
Panakkukang	14.27	75.46	39.39	208.28
Rappocini	0.53	2.82	10.5	56.14
Tallo	2.85	10.82	23.08	87.49
Tamalanrea	27.69	128.09	214.39	991.76
Tamalate	3.01	15.73	65.24	340.79
Ujung Pandang	5.41	20.84	5.41	20.84
Ujung Tanah	1.72	7.22	1.72	7.22
Wajo	0.33	0.86	0.33	0.86
Grand Total	**6.69**	**30.49**	**53.82**	**245.44**

Like the increase in proportion of green area, the inclusion of non-government or non-public space in the space inventory also increases the space per capita. Referring to the World Health Organization standard (Singh et al., 2010) there should be at least $9m^2$/person of open or green space.

Some experiences of world cities that have moved from poor green space provision into acceptable or even good conditions should be inspiration for places like Makassar. Curitiba in Brazil was densely populated and in the 1970s had only $1m^2$ of green space for each citizen. Keen determination to have a better living environment encouraged the development of green space, making it possible for each person to have $51.5m^2$ (Carmona et al., 2004). Canberra in the 1900s was a plain without trees, but with a large planting program following its shift to a state capital, today the city is home for over 200 species of trees making around 400,000 trees in total (Banks and Brack, (2003) cited in Singh et al. (2010)). Similarly, Wellington in New Zealand, and cities in Japan and China share a success story in improving the provision of green space within urban areas (Singh et al., 2010).

Provision of green space in a city could also be related with the affluence of the residents (Matthew McConnachie & Shackleton, 2010). Figure 10.2 illustrates the broad relationship between distribution of green spaces in Makassar and percentage of deprived families in each district. This is a simplified way to achieve a preliminary idea of whether inequality in provision of green spaces for the low income sector of society occurs in Makassar.

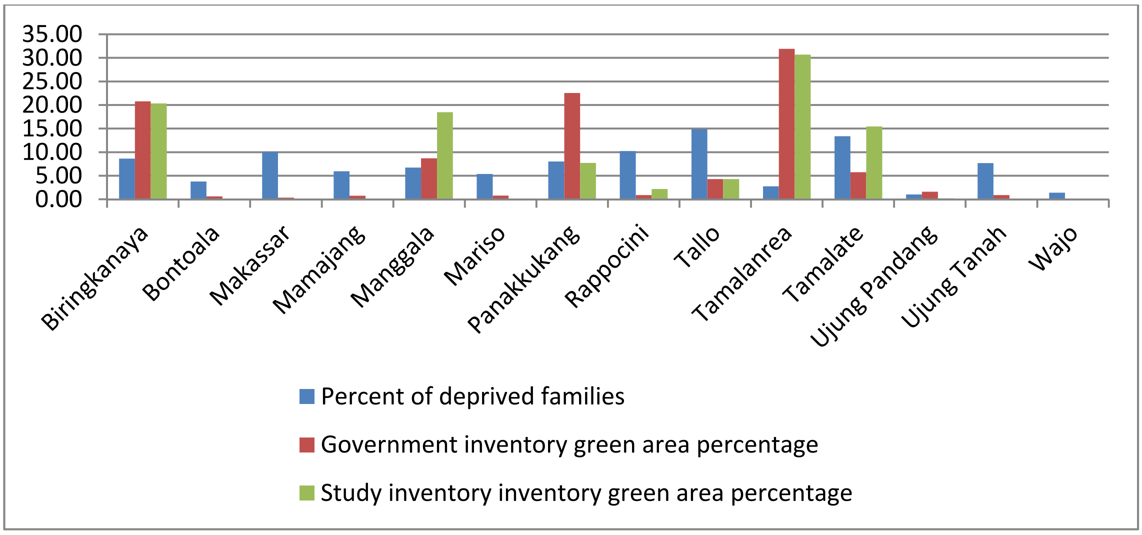

Figure 10.2. Comparison between number of deprived families in Makassar and green areas from both government and study inventory

Figure 10.2 shows that for both government and study inventory spaces there are three districts with large areas of green spaces: Tamalanrea, Biringkanaya and Panakukang, with the study further showing Manggala and Tamalate have significant potential space by considering private spaces as part of the green space inventory. Among these districts, Panakkukang, Manggala and Biringkanaya have a similar level of deprived families, Tamalate has more and Tamalanrea somewhat fewer. On the other hand, Rappocini, Tallo and Makassar are districts where the number of deprived families tends to be greater, yet their green areas seem 'poor' compared to other districts.

This description based on simply comparing green areas and number of deprived households is insufficient to conclude that in Makassar, as in other places (Matthew McConnachie & Shackleton, (2010), deprived families have less opportunity to access green areas. More detailed investigation forms another area for further research.

10.1.2. Further considerations of green space per capita

Although requirements for the proportion of green space in the city have been mentioned in the previous section and in the overview of the city (Chapter 4), it is useful here to develop the comparison of aspects related with green space.

The inclusion of green spots with ecological content in urban areas has become an important attribute of city and urban planning. At the smaller neighbourhood scale, the implementation is based on provision of such space for a certain number of residents (Richard T.T. Forman, 2008) and the fulfilment of several standards (Handley et al., 2003; Harrison et al., 1995) or norms (Singh et al., 2010). Different values adopted by different cities and countries are set out in Table 10.3.

Understanding the significance of green space, some more developed countries have paid attention to its provision and accessibility. The UK regulates a minimum 300m distance from urban settlements to the nearest green space, and a minimum 2 hectare of accessible natural green space per 1000 people (Handley et al., 2003), whereas some European cities provide accessible green spaces within 15 minutes walking (Anonymous, 2005). Based on a habitat model study of Osaka, it is suggested that to achieve an ecologically sustainable city, 10% tree cover throughout the urban area is a sensible target. For individual needs, the World Health Organization (WHO) suggest $9m^2$ of green space should be available per person living in urban areas (Singh et al., 2010).

If the government inventory is used only three districts in Makassar meet the WHO standard, whereas using the study data, half of the districts in the city meet the standard. The green space per capita also increases significantly using the study inventory green areas. Similarly for households, the study inventory shows the availability of green spaces for families is much higher when all spaces regardless of land status are considered and included. Consideration of green spaces for households could be important as the need for natural settings within the urban environment could determine preferences for places to live. Tratsaert (1998), cited by Van Herzele and Wiedemann (2003), reveals the lack of green space and playgrounds for children as a main reason for people leaving a city.

However, this ratio should not just be seen as a number. It should also have a quality of space rating to ensure the green space is really beneficial for people. Handley (2003) underlined qualities of green spaces that are important for urban dwellers such as contact with natural elements, accessibility, safety, and adequate provision of green space for people of all backgrounds. Others have emphasised correlation between provision of green space and access, socio-economic aspects (Martin et al., 2004) and especially welfare, education and ethnical aspects (Barbosa et al., 2007; Martin et al., 2004). Furthermore, in many cases distribution of green spaces is uneven and influenced by factors such as the relative wealth and education of the residents (Matthew McConnachie & Shackleton, 2010). It could be that low income and low educated people do not realize the significance of having green areas around them, or simply that they cannot afford to live in such neighbourhoods because these have been linked to higher property values (Altunkasa & Uslu, 2004; Jim & Chen, 2006; Luttik, 2000).

Table 10.3. Aspects related to green spaces as applied in other countries and cities

Aspects Related to Urban Green Space	**Applied by countries/cities**
Maximum distance to nearby green space	- 280-300 m (English Nature) (Handley et al., 2003; Harrison et al., 1995) - 500 m (Aarhus, Denmark - 400 m (Zurich, Switzerland) (Carmona et al., 2004)
Walking time to nearby green space (accessibility)	- 15 minutes (Europe) (Anonymous, 2005) - 10-15 minutes (Switzerland) (Carmona et al., 2004)
Provision per 1,000 population	- 1 ha (Handley et al., 2003; Harrison et al., 1995) - 0.765 ha (Backer standard in Hidayansyah (2007))
Green space allocation for each urban citizen (Green space per capita)	- 9 m^2 by WHO (Singh et al., 2010) - 200 m^2 in Wellington (Singh et al., 2010) - 104 m^2 (Europe) (Konijnendijk, 2003) - 800 m^2 (France) (Konijnendijk, 2003) - 80 m^2 (Canberra-Australia) (Singh et al., 2010) - 10 m^2 (Harrison et al., 1995) - 8 m^2 (Zurich, Switzerland)(Carmona et al., 2004) - 38 m^2 (India)* (Singh et al., 2010) - 3 m^2 (Hong Kong) (Singh et al., 2010) - 27.3 m^2 (China)** (Singh et al., 2010) - 1.9 m^2 (Malaysia) (Purnomohadi, 2006) *** - 5.0 m^2 (Japan) (Purnomohadi, 2006) *** - 11.5 m^2 (Lancashire, England)(Purnomohadi, 2006) *** - 60 m^2 (USA) (Purnomohadi, 2006) *** - 1.5 m^2 (Jakarta, Indonesia) (Purnomohadi, 2006) *** - 17.3 m^2 (Makassar, Indonesia) (Hidayansyah, 2007) ***

Table 10.3. Continued

Trees/crown coverage	- 27% (USA) (Singh et al., 2010) - 18.6% (average in Europe) (Singh et al., 2010) and 1.5 to 62% (Pauleit et al., 2002) - 27.85% (India)* (Singh et al., 2010) - 1.81% (Hong Kong) (Singh et al., 2010) - 32.54% (China) (Singh et al., 2010)
Target for green space proportion	- New York: 25,2% (by 2020) - Tokyo (32%, 2015) - London (39% , 2020) - Singapore (56%, 2034) - Beijing (43%, 2050) - Curitiba (30%, 2020) (Cahyo, 2011)
Number of Trees per dweller	- 23 (China) (Singh et al., 2010)
Ownership and Management	- Split responsibility (as in Hannover, Groningen) - Temporary use (as in Tokyo) - Independent board (as in city of Minneapolis) - Government agencies (as in Tokyo, Melbourne) (Carmona et al., 2004)
Community involvement	- Voluntary neighbourhood board - Local partnership (as in Curitiba) - Involvement in green space appraisal (as in Groningen) - Participation through design (Malmo and Zurich) - Park activity councils - Volunteer rangers (as in Wellington) - Special events (Hannover) (Carmona et al., 2004)

Source: various references as cited
* Average measure of 2 main regions: Delhi and Chandigarh
** Average measure of 2 main cities: Nanjing and Wuhan
*** Regulated value

Based on the discussion above, it is clear that inclusion of all potential open space whatever the land status is essential. Consequently, this study has identified all spaces which could have potential for inclusion in total urban green space, given the government is able to impose policy and arrangements for private and corporate space utilization for the sake of the city, as happens in Japan. This could be inclusion of underused private spaces or temporary use of vacant land (Carmona et al., 2004). In the Makassar context it could include their utilization through government assisted improvement for cultural spaces such as agriculture fields and fishponds.

The standard set by the Ministry of Public Works in 1987 (Hidayansyah, 2007), which prescribed 17.3m^2/person of open space, is only achievable for Makassar when all spaces regardless of land status are included. The study by Hidayansyah (2007) also revealed that fulfilment of the Indonesian Ministry of Domestic Affairs instruction for

30% green space is only achievable if all spaces are counted, even those not managed by the city council.

10.2. Improvement of the spaces

The preferred spaces as explained in Section 9.1 are those with high biodiversity and that are likely to be preferred by urban birds, but they have issues in terms of management and policy as a result of their various sizes and ownership status. As they are considered to have the most potential, they are also expected to form part of a proposed network as described in Section 9.2. Nevertheless, using the principle that all available open spaces are important for the city, efforts for improving the quality of all available spaces should be considered, not only the most preferred ones.

All spaces have been classified into a typology according to their characteristics and physical condition (see Chapter 5). This classification, including spaces acknowledged by the government (see Section 10.1.1), shows a few typologies dominate the open space in the city. Figure 10.3 shows these are urban farms and fishponds. As mentioned before, these also contribute significantly to the city's food supply, therefore from this perspective their presence and performance need to be maintained. On the other hand, many sources (Krisp, 2002; Pattanavibool et al., 2004; Vuilleumier & Prélaz-Droux, 2002) have discussed agricultural fields as one cause of habitat fragmentation and reduction in landscape structure diversity. This is due to the nature of agriculture fields where vegetation tends to be homogenous and less diverse. Observation in Makassar urban farms generally conforms to these descriptions.

Likewise, fishponds are monotonous and bare, with vegetation existence hardly visible. Similar to most fish ponds in Indonesia, those in Makassar seemed to have been developed and constructed without regard to the environment. Clearing of mangrove-type plant masses (Nypa palm) for aquaculture has disrupted the lives of a variety of wildlife, including the fish and shrimp which are strongly associated with the provision of seeds for farm activities (Puspita et al., 2005). The trace of this palm mass fragmentation by the fish ponds is clearly observable, especially along riversides.

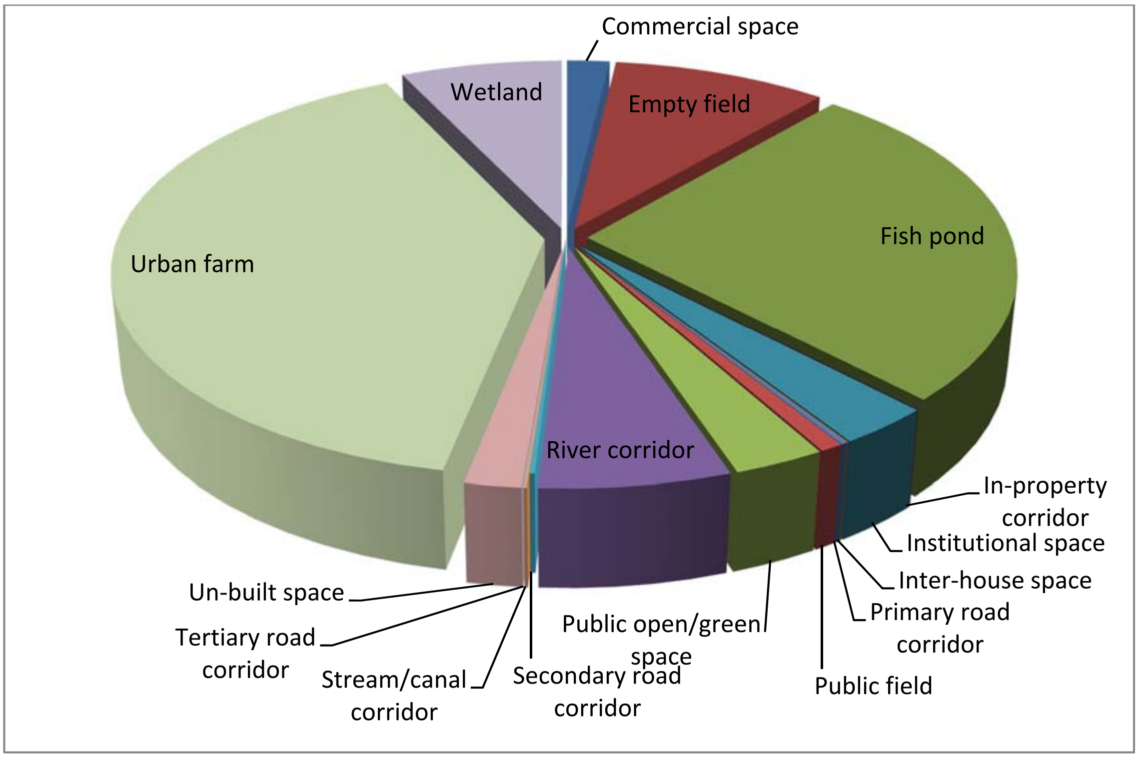

Figure 10.3 Proportional breakdown of space typology in Makassar

Nevertheless, people have tried to find ways of improving agricultural activities in order to make them more valuable in terms of environment and ecology. The following are some improvement techniques and methods introduced and applied in other places. These methods have not been specifically tested for their application in a city like Makassar, and their application might also depend on certain required conditions which may not be available. Nevertheless, the principles are worth looking at and could lead to future investigation into their compatibility and feasibility for adaptation and application in Makassar or similar cities.

10.2.1. Improving agricultural fields with buffers and agroforestry principles

Agricultural fields in Makassar, especially paddy fields, are open fields with poor diversity of plants other than the agricultural commodity. The openness provides less opportunity for the site to carry even a small function as a site of refuge for wildlife. In fact in paddy fields there are non-planted areas as well as the borders that might be utilized for planting vegetation with specific ecological benefits. Nevertheless it is important to select carefully types of plant that will not harbour pests which could threaten the farming. According to USDA guidelines (Bentrup, 2008), conservation buffers are strips of vegetation planted in the landscape of fields to effect ecological processes favourably and provide a variety of goods and services to people and the ecosystem.

Figure 10.4. Conservation buffer in agricultural fields (Source: Bentrup (2008))

For agriculture fields around streams, these buffers could also serve as barriers that protect the streams from unfavourable effects of farming activities such as spray drift, which may harm non target species as well as stream water. Although pest carrier plants are an important concern, conservation buffers could serve as weed control agents and become homes for beneficial insects. In the event of overflow, riparian buffers can slow the run off and absorb excess water, hence reducing the threat of flooding to the farm fields (Bentrup, 2008), although this may be of less concern for paddy fields..

Figure 10.5. Samples of urban farms in Makassar showing un-planted areas where conservation buffers are possible (right) and not possible because of proximity to buildings (left).

Urban farms in Makassar could also be improved by introducing fencing plants around the fields, also known as windbreak layers. Although wind in this city is not a serious regular threat, when rows of plant are appropriately established in farm fields, windbreaks can improve farm income opportunities and the environment. They form a 'fence' that both defines property lines and creates wildlife habitat (Idassi, 2012).

Figure 10.6. Windbreaks or fencing plants can be both functional and aesthetic
(Source: Idassi (2012))

Most urban farms in Makassar do not have wide strips of available land on the border for planting dense vegetation as suggested by the guidelines. However a strip of trees could produce a screening effect and make a good barrier while hosting certain non-threatening animal species.

Well planned agriculture fields can also play an important role in the hydrological cycle, micro climate and local ecology, and where possible these should be formed of remnant habitat (Knowd, Mason, & Docking, 2006). Even further, Pauleit (2003) was convinced that despite being distinctively different from other urban green spaces in terms of the character, an urban farm can be managed as other green space to provide recreational and environmental benefits. An example for good environmental farming, including application of agroforestry methods to an agricultural system integrated with a riparian system is shown in Figure 10.7.

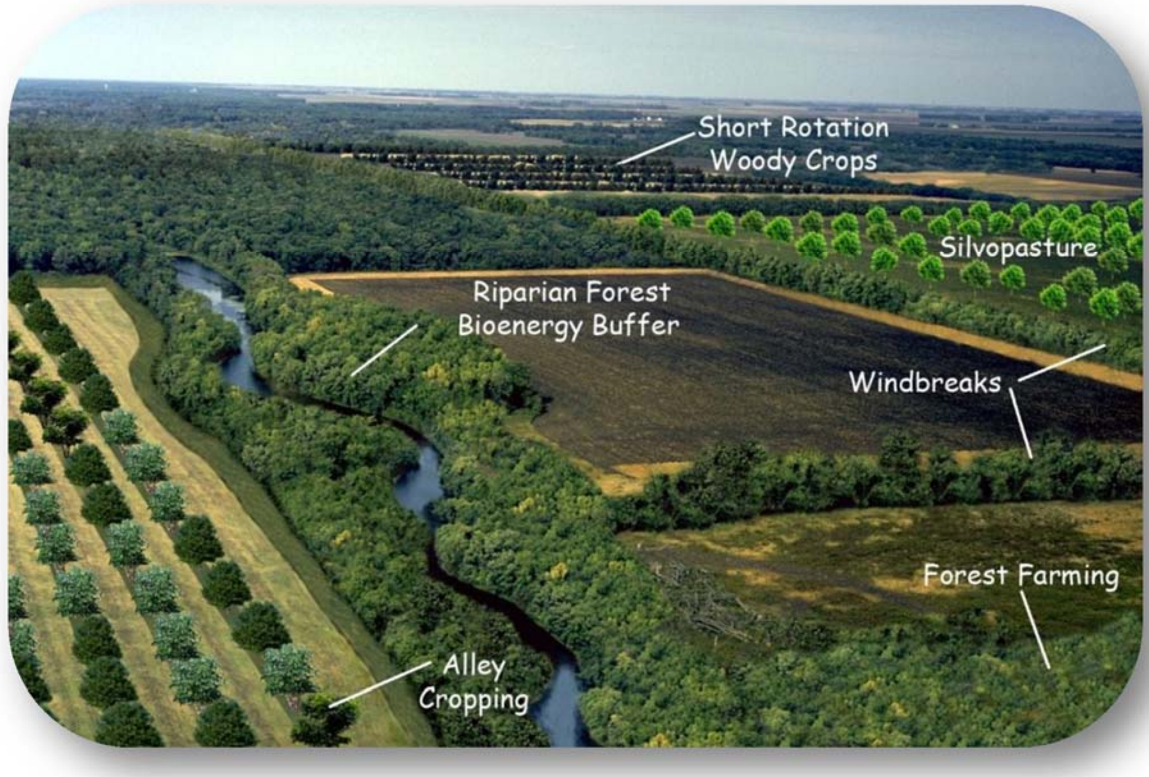

Figure 10.7. Agroforestry applications on the farm
(Source: National Agroforestry Center (No date))

10. 2.2. Improving fish ponds with a silvo-fishery approach

Most fish ponds are established by clearing the mangroves which naturally inhabit the area, which has serious implications for the environment. Conventional fish culture in ponds according to Puspita et al. (2005) is highly profitable only in the short term. It is important to use more ecological techniques, which at the same time are favourable for the environment, to ensure long-term profit. Initiatives for improving the ecological value of fishponds have been started in certain areas in Java through the silvofishery technique (Puspita et al., 2005). Basically this means re-establishing the mangroves. Silvofishery (Figure 10.8.) provides ecological and economic benefits. Ecologically, the fish ponds return the function and role of mangroves in the area. Economically, the application of this technique has proved to give better profit to farmers in three regencies of Central Java where it was tried. Apart from cultured fish, farmers also benefit from the wild fish and shrimps whose existence is induced by the mangroves.

Another thing to consider is to limit or totally stop the creation of new fish ponds along rivers in Makassar. As an alternative, the introduction of coastal fish ponds would prevent further intrusion and fragmentation of natural river corridors. According to a trial in Ujung Genteng Village, Sukabumi (West Java) fish ponds in sandy land are more constantly productive in the long term. The technique used is known as BIOSEAL (Bottom Isolation from Organic Substances to Eliminate Acid Layer) (Trihono & Chaidir, 2004).

Figure 10.8. Fish ponds adopting the silvo-fishery approach in Central Java, Indonesia
(Source: Puspita et. al. (2005))

Coastal silvofishery fishponds are also recommended by Wetlands International as they can be integrated with mangrove planting along the coast. This approach has been introduced to two provinces of Indonesia (Aceh and Nias) and is considered to be both environmentally friendly and have additional benefits. The application of coastal silvofishery is shown in Figure 10.9.

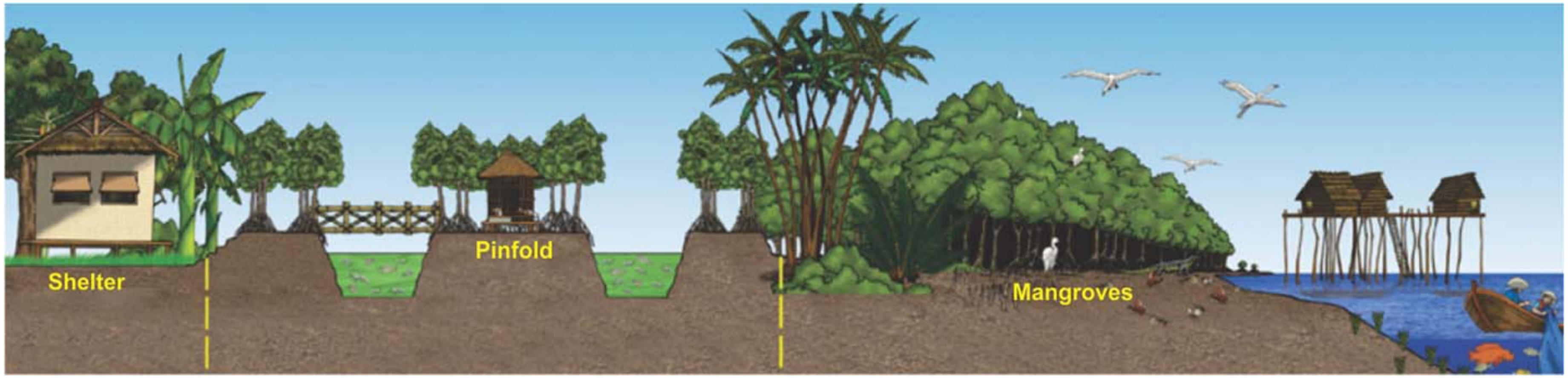

Figure 10.9. Coastal silvo-fishery as an environmentally friendly approach for a green coastal area
(Source: Wetlands International (2002))

In Figure 10.9 the well vegetated area around the shelter provides cooler and more comfortable accommodation for the farmers, thus reducing their stress. Planting productive plants such as banana around the shelter provides additional income. The shelter is also better protected against high winds. Planting in the pond dikes also creates a cooler and more comfortable environment, and gives additional income. At the same time, the embankment is reinforced by the roots of the plants and this is proven to improve the productivity of the ponds. The taller plants around the ponds also control the temperature of the water and create a better environment for fish. Dense mangroves along the coastline serve as habitat for certain native species, protect the coast against erosion, and contribute to cleaner water. The mangroves also protect the land from wind, storm and waves. Litter from the mangroves improves water prolificacy and hence increases the fish population and the catch. The mangroves also make the coast greener and have a better visual quality, which creates opportunities for tourism (Wetlands International, 2002).

10.2.3. Improving river and stream corridors

Rivers are important as a river is one feature that can potentially connect spaces in the main city of Makassar to the more natural landscape outside, even leading to nature reserves within the greater urban region. However river corridors in the city as well as those in the more rural areas are not in a favourable condition and some are even poor in terms of the disturbances that have occurred to these natural corridors. Figure 10.10 shows the condition of river corridors in Makassar and the greater urban region.

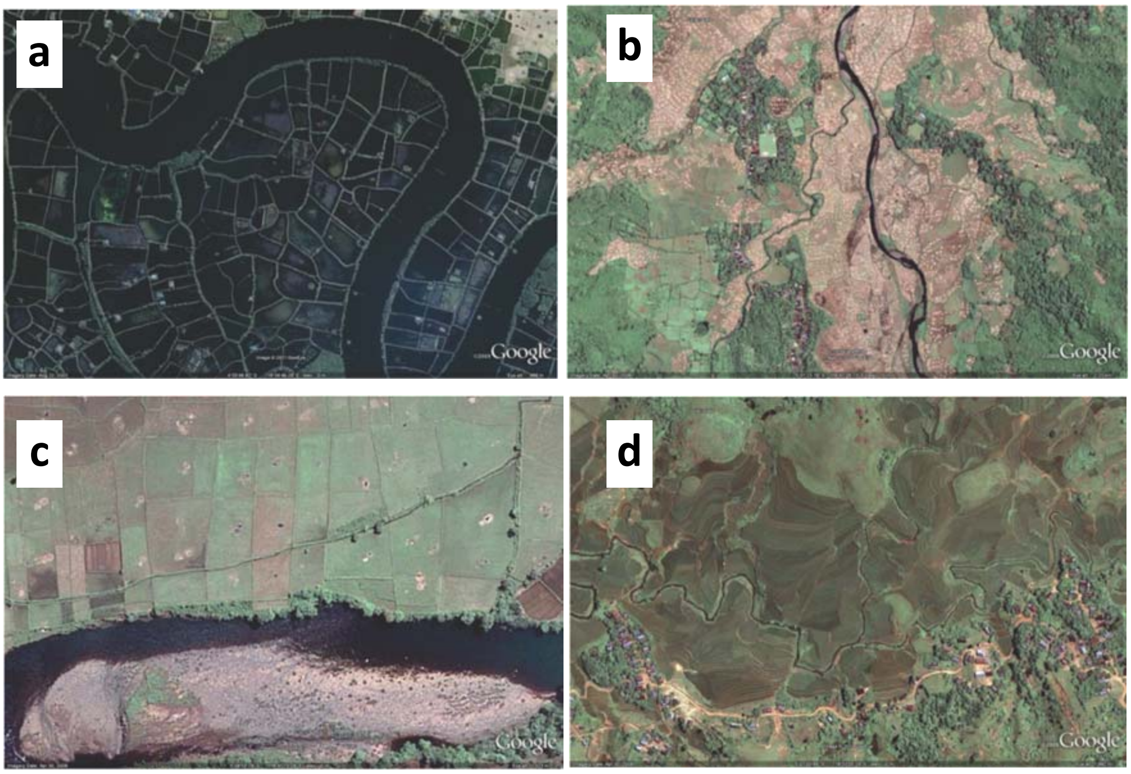

Figure 10.10. River corridors in Makassar and outside the main city within Mamminasata greater urban region (Source:google earth, 2011)

Figure 10.10 shows different land uses along rivers and streams in Makassar and in the adjoining regencies. Picture **a** shows fish ponds along the Tallo, the main river of Makassar. The fragmentation of the natural Nypa palm is severe, leaving scattered patches of remnants, some of which are protected through conservation policies (Lakkang conservation area), while others are still under threat of further intrusion. Picture **b** shows cleared land for agriculture fields along streams in the Regency of Maros. This is quite alarming since the streams are located near the natural park of Bantimurung. Picture **c** shows rice fields along rivers in Gowa and picture **d** shows streams enclosed by a rain-fed paddy field system of terraces in the sloping areas surrounded by protected forest on one side and a matrix of settlements and mixed-crop farms on the other, also in the Regency of Gowa.

The improvement of river corridors to ensure their feasibility as ecological channels that connect patches across the landscape is important and strongly recommended. In developed countries, river corridors and riparian areas have been viewed as important corridors for ecosystems, hence governments have imposed standards for buffers and planting guides in these areas. One example of a suggested stream corridor appears in the Urban Greening Manual for New Zealand developers (Maria Ignatieva et al., 2008), in which the existence of native species is emphasized along with the allocation of a species zone whose width and composition depends on the size of the river or stream.

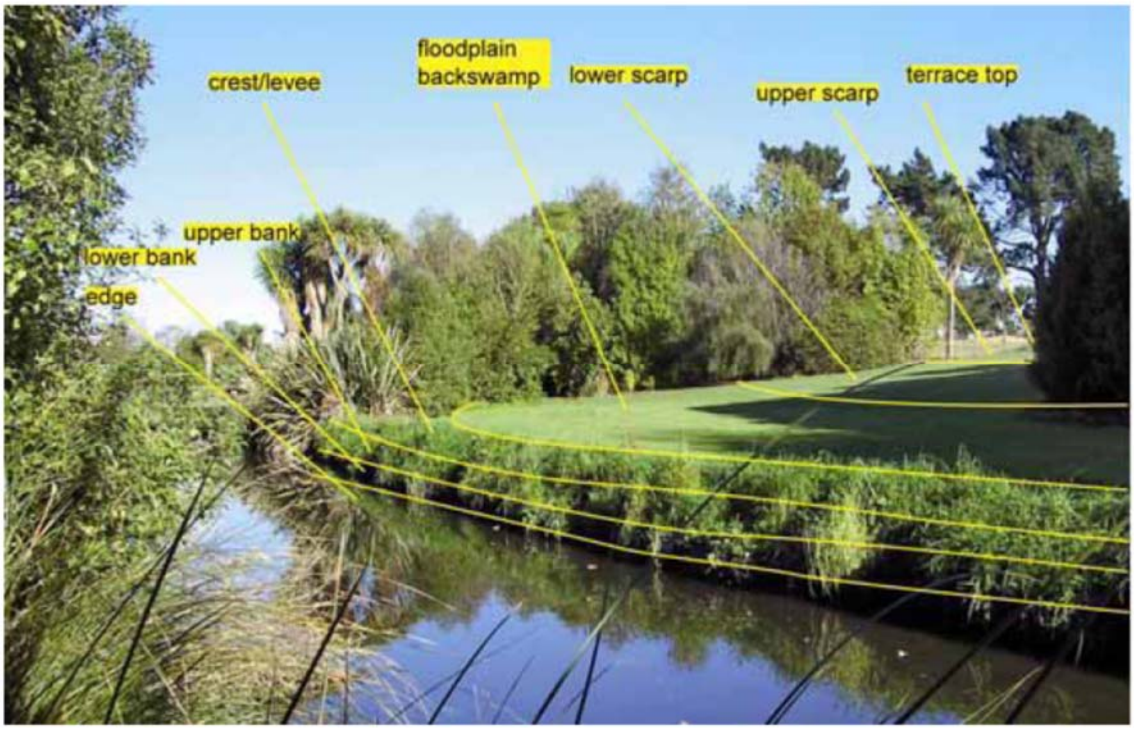

Figure 10.11. Riparian planting zones in Heathcote River, Christchurch, New Zealand
(Source: Ignatieva et al. (2008))

Planting along river corridors is also carefully determined according to topography-based zoning which considers the normal and overflow conditions as illustrated in Figure 10.12.

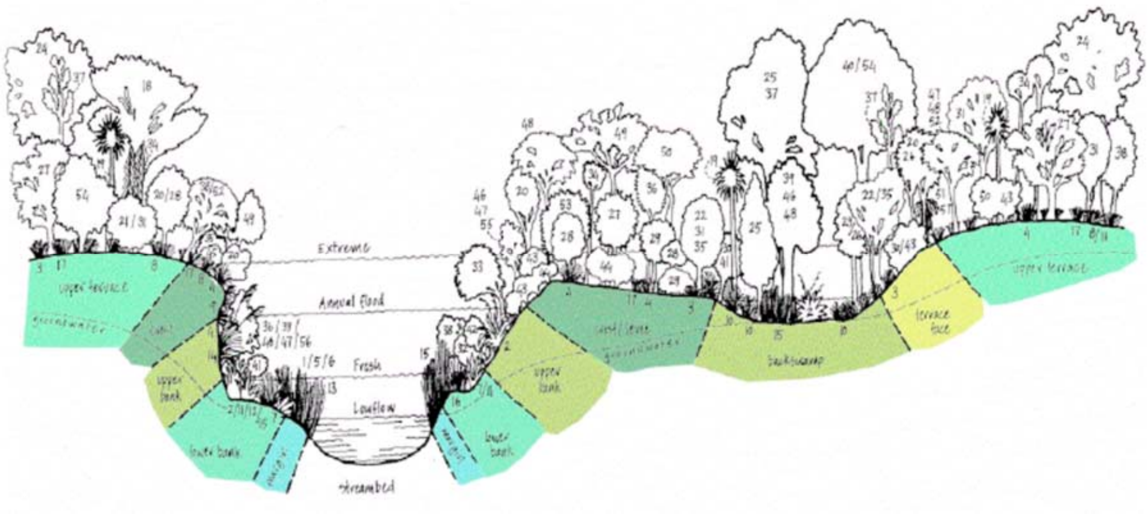

Figure 10.12. Idealised stream profile of different river bank zones
(Source: Christchurch City Council Streamside Planting Guide in Ignatieva et al. (2008))

The following figure shows other river and stream conditions in New Zealand which would be good examples for river corridor development and improvement in Makassar.

Figure 10.13. Two examples of river and stream corridors in Wellington: wide buffer for river corridors in Lower Hutt (left), and small stream in Karori with dense vegetation providing shelter for animals (right)

Naturalization of stream and river banks would help to create natural corridors through reclaiming the edge area while at the same time promoting habitat. Provided protection and disturbance prevention measures are available, river corridors are also valuable for social and recreational services.

10.2.4. Improving road corridors

The main problem of roads in Makassar is lack of space for side planting and median planting. Roadsides have become narrower following road expansion projects in response to increasing traffic in the city. In fact road extension can never be a permanent solution as the growth in vehicles far exceeds that of road infrastructure. Therefore road corridor improvements require integrated solutions with traffic management systems, such as the introduction of a better public transport system. Where road expansion is not planned, road corridors could be an important part of a functioning green or ecological network as shown in Figure 10.14. Roads leading to rural areas outside Makassar have better potential for roadside improvement and green corridor establishment.

Figure 10.14. Green road corridors in Wellington city leading to green belt patch on hillside
(Source: NZ Transport Agency (2012); Google earth, 2012)

Enrichment of road corridors could result in many benefits and functions. The vegetation alongside roads could be planted not merely for creation of corridors but also for utilizing spaces for specific purpose. A good example is how native 'harakeke' or flax (*Phormium tenax*) has been extensively planted in highway corridors as well as in urban green spaces in Wellington city in order to attract 'Tui' as a one of the distinct native birds of New Zealand. Although a forest bird, this species is now commonly observed in Wellington and the Tui population has been growing significantly (Fairfax New Zealand News, 2008). This has improved the opportunity for sighting of more native species, such as Kereru, as many have made a long awaited return to the city

(Brown, 2012). Understanding the Tui habitat and ‘willingness’ to occasionally visit the city, people are facilitating this by creating corridors for the birds which connect green patches near the urbanized centre of the city to the Botanical Gardens and finally to the woods in the town belt. Figure 10.15 illustrates how such connecting features work in an urbanized city like Wellington where having this forest bird in a human-dominated landscape area is special. From Figure 10.15, in order to attract them, flax was planted in a small patch of green space (A). Tui could come from a temporary refuge within the bulk trees in patch B which links to patch C, which also has large trees as well as flax planted along the highway. This creates a route for the species as well as features that attract them as Tui feed on the nectar in flax flowers. Therefore, the long narrow patches B and C, which are green patches as well as green corridors along roads, serve as ‘pathways’ for the bird. The corridor B and C allows for their movement to and from the Botanical Gardens (D) as a large stopping place before they hop over to the main target patch, the woods in the town green belt (E). This creation of green corridors and stepping stones of favourable spaces is also a part of Low Impact Urban Design and Development (LIUDD) initiatives to encourage native birds back into cities (Maria Ignatieva et al., 2008).

Introduction of street trees would not only be for green corridors. One benefit of having trees as a substitute for rigid infrastructure, is that trees are more effective as they grow while infrastructure depreciates as it ages (Gregory Mc Pherson, 1992). For example, the use of trees as temporary shade over a bus stop or parking area is more cost effective than using a roofed metal shelter.

10.2.5. Improving all other typologies

As every natural spot regardless of size has potential to be part of a network (Carmona et al., 2004), it is important to consider possible improvement of all other typologies. Having performed field observation as well as different stages of assessment and analysis, a summary of these typologies including suggestions for improvement is presented in Table 10.4.

Figure 10.15. Illustration of corridors for Tui (*Prosthemadera novaeseelandiae*) in Wellington through planting of 'harakeke' flax (*Phormium tenax*).
Right: Tui and flax flowers; planting of flax on highway roadsides
(Source: Google earth 2012;; Department of Conservation & Gerbeaux (2006); Squid (2011)

Table 10.4. Summary of properties of spaces in Makassar according to assessment and observation

Typology	Percentage of all identified spaces (%)	Level of Biodiversity (see Section 8.1)	General Current Condition	Issues/ Concerns	Possible Improvement
Urban farm	39.84	- High	- Mainly paddy fields with few fields for mixed crops - Their existence is significant for city food production, hence conversion to either natural areas or built areas would not be appropriate.	- Despite scoring high in plant biodiversity, agricultural fields tend to be homogeneous and less diverse. - Farming practices which use technology with excessive use of chemicals as well as intensive farming systems might not suitable for some species to thrive - As witnessed in some parts of the city, urban farms are vulnerable for land conversion into other uses, mostly for settlements and business sites.	- Improvement in farming practice by adapting environmentally friendly farming systems might improve the ecology of urban farms in Makassar. - Utilization of field borders for planting dense vegetation might improve the ecology, but it is important to consider interference with yields from pest hosting plants.
Fish ponds	26.61	Medium	- Like most fishponds in Indonesia, there is a basic lack of vegetation making them ecologically poor. In fact fishponds in Makassar have encroached on natural mangrove (Nypa palm) in the river corridors	- This is the main feature that seems responsible for the fragmentation of natural river corridors. - Fishpond management which neglects environmental concerns as in many Indonesian cities (Puspita, Ratnawati, Suryadiputra, & Meutia (2005) will have short profitable periods as opposed to fishponds managed with ecological and environmental concerns. - Encroachment of river corridor through establishment of new fish ponds is possibly still on going.	- Silvofishery is an approach which has been introduced for fishponds in certain areas in Java. This runs fish culture along with mangroves within one site - Some studies found fish ponds in sandy based soils are more viable for fish and shrimp production compared to those in clay based soil. This could be an important consideration for local authorities for shifting the centres of future fishpond culture from alongside rivers to coastal areas

Table 10.4. Continued

Typology	Percentage of all identified spaces (%)	Level of Biodiversity (see Section 8.1)	General Current Condition	Issues/ Concerns	Possible Improvement
Wetland	7.09	High	- Most wetlands in the city serve as water catchments, which also suffer from encroachment by residential building construction.	- The nature of wetlands make them less suitable for building construction, although some wetland areas in the city were filled in prior to development causing them to lose their surface run-off water absorption function. - The conversion of wetlands is a serious threat for the city and has been claimed as the cause of annual flooding in some areas.	- Wetlands are a good refuge for wildlife, especially when not disturbed by humans, offering opportunity to improve their carrying capacity for harbouring various species and increasing their ecological value. - It is important for the city to first to protect the remaining wetlands from conversion before improving their physical conditions.
Empty field and un-built space	9.42% and 1.82%	High	- Most are either abandoned fields or sites awaiting development - Un-built spaces are those near residential areas or within residential complexes which according to field observation are likely to undergo development or conversion in the near future	- The uncertainty about the future of empty fields is due to their status which depends on the owners' decisions. - They represent a dilemma as they can be developed at any moment but some have been abandoned for a long time from the assemblages of plants which have appeared, leading to a high biodiversity score. - Without proper enforcement of established green space provision regulations for residential areas, it is possible all un-built spaces will be converted for housing without green spaces or parks	- It is important to identify empty spaces which are not going to be built on for significant amounts of time and use these spaces for green/ecological spots. - Although currently government cannot regulate private land, campaigns about the importance of having green areas can be made. - Learning from other countries (as in Carmona et al. (2004) and Dutch Ministry of Agriculture (Natura, 2000)) means government arrangements with the owners can propose green/ecological utilization within a significant long-term contract, in a way similar to telecommunication companies' arrangements for setting up transmission towers within private spaces which have been a common practice in Indonesia.

Table 10.4. Continued

Typology	% of spaces	Level of Biodiversity	General Current Condition	Issues/ Concerns	Possible Improvement
River Corridors	6.10%	High (assumed based on other typologies that occupy most river corridors)	- Encroached on by agricultural fields such as fish ponds and farm/paddy fields - Some patches are remnants of natural masses of Nypa palm, and other mangrove-type plants near the estuaries	- Land status of area around the river (mostly private or corporate) means government has no control over them. Regulation on water catchment and floodplain areas means these should be free from activities and utilization that might threaten their function for flood control. - Over flow during heavy rainy season can cause flooding, therefore clearing areas by river corridors for conservation/protection buffers is important, yet hardly found in Makassar. - Rivers are an important feature connecting highly urbanised spaces in Makassar with more natural rural areas. Therefore if Makassar is to realize an ecological network in the future, river corridors are the first feature/typology to be considered as a connecting feature.	- Government plan to introduce tourism for the main river (Tallo River) and its conservation are an added attribute, as having green corridors along the river would increase its value. Development plans for river based tourism are not necessarily detrimental for ecology if done carefully. - Acknowledgement of conservation areas (such as Lakkang conservation zone) is a good start for further preservation - For corridors which are not part of the tourism development plan, it is important the government preserves whatever remains and stops further encroachment for new settlements or other purposes - Introduction of improved management of all cultural activities along the river (such as environmentally friendly agriculture and fish ponds) as developed in other Indonesian regions and overseas. - General naturalization of river banks to reclaim the disturbed/fragmented natural corridors.
Institutional space	3.04%	High	- Open access spaces within institutions tend to be well landscaped for aesthetics. This is less good for habitats and ecological spots - Campus grounds are often less designed. A large Makassar campus ground is officially part of the city's urban forest	- As non-public and non-state owned spaces that are likely to work with the government, it is important to involve more institutions in seeing their spaces as part of the city's green spaces. - Private business institution participation might require agreement with the government in terms of management and maintenance. - Involvement of the government is always necessary as green initiatives like other policy dissemination mostly work well with a top-down approach. The initiative has to be started by government institutions in order to stimulate the private institutions.	- The most ideal condition for inclusion of institutional space into a green network is self-management which will not cost the tax-payer money. In order to stimulate this, government could introduce programs and campaigns such as eco campus/school, green office/building or a 'one employee one tree program' (adapted from 'one house one tree', an on-going campaign). - Government appreciation towards participating institutions can be expressed through certificates, official public announcements and awards which could be given through competition (adapted from on-going neighbourhood competition for greenness and cleanliness).

Table 10.4. Continued

Typology	Percentage of all identified spaces (%)	Level of Biodiversity (see Section 8.1)	General Current Condition	Issues/ Concerns	Possible Improvement
Public/open green space	2.94%	Medium	- Most are parks and green spaces whether large or small, from city park to small neighbourhood garden	- As observed throughout the city, most public green spaces are mainly for recreational purposes and their aesthetics reflect this through use of exotic plants, formal design and high accessibility. This is not favourable from an ecological point of view. - Similar to the importance of preserving fish ponds and urban farms for their role in food production, public green space needs to be maintained and even improved, because humans as the main urban inhabitants need their amenity value.	- The current available public green spaces in Makassar should persist in providing social benefits for the people, but could become part of a stepping stone corridor for urban birds. To optimize this function introduction of big trees and dense vegetation in public parks would be of great assistance for birds and other possible urban species. - Introduction of multi-purpose parks would be a good approach for using their function for both humans and wildlife. This requires a significantly large area for any new parks.
Commercial space	1.87%	Low	- Most are spaces in business sites and shopping malls	- They are mostly not green, as the spaces might be destined for other purposes such as loading areas or parking.	- As parking is normally an integrated part of this type of space, improvement is by planting trees which provide shade for cars and could have an ecological function.
Public field	0.75%	Medium	- In Makassar, there is one large official public field (Karebosi) and many 'emerged' fields within settlements	- This is space for dynamic activities such as sports and gathering, hence they are not good for contact with plants or animals. However vegetation like trees can be further introduced for amenity and aesthetic values.	- If the government allocates official space for sports and community gathering to serve each community, then spaces which previously served as public fields could be converted into green spaces such as neighbourhood gardens.

Table 10.4. Continued

Typology	Percentage of all identified spaces (%)	Level of Biodiversity (see Section 8.1)	General Current Condition	Issues/ Concerns	Possible Improvement
Inter-house spaces and in-property corridors	0.05%	Low	- Most are house yards	- The low percentage of this type among all identified spaces in Makassar does not necessarily mean their existence is not significant. Here they are less prioritized due to their low biodiversity score, typically small size and lack of accessibility for surveying. - As in other cities, house yards make a significant total area and according to Gaston, Warren, Thompson, & Smith (2005) they constitute a large extent of 'green space' in urban areas and are of potential significance for the maintenance of biodiversity in cities. - Although acknowledged in the decree of Minister of Public Works (2008) their inclusion as part of the city's green space has not been arranged or regulated.	- Again, participation of people is important, so it is vital for the government to inform people about the significance of every patch by their house. - Campaigns could inspire communities about the importance of their house yard for the city in general. At a certain level this understanding could increase enthusiasm for keeping at least part of their house yard green and enriching the vegetation. - Well vegetated house yards form a potential corridors for biodiversity (Rudd et al., 2002). They contribute significantly to the overall green network size through improved connectivity of private yards functioning as corridors or patches (Singh et al., 2010). This study identified these as in-property corridors. Enrichment and improvement of these together with vegetation along residential roads would make stronger corridors for the city's green network. This would save energy and space for habitat through connecting greenery by houses (Maria Ignatieva et al., 2008).
Stream/ Canal	0.06%	Medium	- Most are canalized streams, although streams with earth embankments still exist	- Canalization of a stream is not favourable for biodiversity (Puspita et al., 2005). It destroys natural elements and makes way for human activities and built structures to come to the very edge of the stream.	- While it is difficult to return a canalized stream to its previous state, it is important to preserve streams with natural banks. Planting the corridor with massive plants would possibly stop development toward its edge.

Table 10.4. Continued

Typology	Percentage of all identified spaces (%)	Level of Biodiversity (see Section 8.1)	General Current Condition	Issues/ Concerns	Possible Improvement
Road corridors (Primary, secondary and tertiary roads)	0.2% or less	Low	- Primary roads were expected to have wide corridors but appear to be deprived of planting opportunities at their sides or in the median - Some points in the main highway have potential to be good corridors, yet continuity is another issue	- The three types of road: primary, secondary and tertiary all scored low in biodiversity mainly due to the massive existence of built structures (road, pavement, buildings). This does not matter as long as spaces are available along roads are utilized for the creation of green corridors. - Road expansion and widening projects have caused the narrowing of roadside land available for planting; as witnessed in the city, significant numbers of roadside and median trees have been cut down in road extension projects and this practice needs to stop.	- In terms of vegetation structure, tertiary roads (mostly residential roads) have more diverse and dense plants with a significant contribution from in-property vegetation. Therefore integration of the potential green corridors of residential roads and houses is important. - Due to land availability and increase in traffic, roads within the city might not be suitable for the creation of good corridors for ecology; however roads leading to rural and more natural areas outside the city might have greater potential. Therefore in addition to river corridors, these should be considered for connecting the green network to ecological areas in the greater urban region outside Makassar.

Table 10.4 shows the suggested efforts for improvement are mostly physical. However management is also as important to increase their ecological quality for eventual inclusion into a form of ecological network.

10.3. Summary

This study has identified spaces which are considered to have potential for the city: the most preferred spaces. The previous chapter showed how these spaces might be linked, and this chapter presents two further aspects to consider. Firstly, the inclusion of all preferred spaces would significantly affect the fulfillment of green space per head of population standards in Makassar. This finding stimulates the need for further study in this area. Secondly, this chapter provides examples from other places to show how improvement can be made to significant typologies for the city of Makassar, along with suggestions for improving the rest of the typologies. Some examples are from a developed world context, which may differ from the tropical condition in Indonesia, however the principles are valid, and again their application in a developing and tropical context forms an area for further research.

Chapter 11

Conclusions

Taking a fast growing city in Indonesia as the study location, this thesis provides a description of the ways to evaluate spaces in a developing city and the stages necessary for undertaking the assessment. This assessment is driven by an initial intention to see the applicability of the concept of a network of green spaces and the ecological benefits this might bring to a developing country city. Analysis of the many related factors also leads to an understanding of certain issues related to urban development and its management in the developing country context of Indonesia. The prescribed steps of assessment demonstrated by this study also bring forward the need to investigate other aspects and issues which are potential areas for further research.

11.1. Answering the research questions

The study was based on the main question: ***"Can a greenway or an ecological network be accommodated in a city in a developing country?"*** Having assessed Makassar by looking at many aspects in terms of space availability, there are potential spaces that can be included into some type of green space network that favours the preservation of nature. An important finding of this research is the understanding of the real potential of the green spaces the city already contains. Comparison of the inventory of green spaces made by this study and that of the government confirms a significant disparity between them. The difference mainly relates to the exclusion of non-public spaces and other spaces beyond government control in the government inventory. It is common for authorities in Indonesian cities only to consider spaces under their management for any program related to green spaces in their city.

Out of the total area of the city (17,476.01 ha), this study identified the available spaces were **7,208.58 ha**. After applying filters to find the best spaces, this still left **4,616.97 ha**. These values are far above the government inventory which is only accounted for **895.48 ha.**

When all available spaces are taken into account, **41.25%** of the city is open or green space as opposed to only **5.12%** according to the government inventory of public spaces. Furthermore, the most preferred spaces constitute **26.42%** of the city area and merely taking these spaces already exceeds the required standard by the Ministry of Home Affairs.

Based on this finding it is possible to consider the city of Makassar has available green spaces which are ready to be utilized within one connected system. The next step was then to determine what sort of network could be achieved.

Having assessed the biodiversity of the two main elements of a green space network—patches and corridors—using a rapid assessment method and also importantly through visual observation during the fieldwork (see Section 9.3), this study concludes that currently an ecological network for the city is not feasible because of the condition of the green and open spaces that make up the patches and corridors. Even a greenway along the main river corridor is not currently feasible because the highly valuable natural remnants have been significantly fragmented by cultural activities, such as farming and fishponds. Similarly, the road corridors are also not currently in as promising condition.

However, the local authority could use these spaces as the starting point for making a green spaces network in the future. This study also suggests actions that might drive this course in the form of patch and corridor improvements. There is also an opportunity to link up the green spaces in the city to the areas outside it, and even as far as two existing national parks of high ecological value.

The further research questions are also answered as follows.

- Are there existing patches and corridors? and what is their condition?

Yes, the city has existing patches of both public and private spaces (see Figures 5.22). In terms of the size, the most significant are the cultural fields of farms and fish ponds. For ease of management, public parks, urban forests, institutional spaces and other spaces under government control have the best potential despite their lower existing biodiversity. However, when functional consideration is given priority through the creation of a connecting system in the form of a network, the public ownership of land is not required or implied. Instead, private land, especially farms and wooded areas, have an important role in green space systems (Benedict & McMahon, 2002). The fact the city council and authority currently have no power to control non-public space regardless of whether it is part of a network or not, is not exclusive to Makassar. This is a common problem in other Indonesian cities, and possibly other cities in developing countries.

- How could their condition and quality be assessed based on the resources available?

Assessment of spaces was done through several stages to obtain the most preferred spaces. The main aspect assessed was biodiversity which was assessed with Rapid Biodiversity Assessment (RBA). The RBA was developed in the UK and had to be adapted for this study. With several adjustments and simplifications to reflect the limited time and resources (Chapter 6) this method is applicable for the study location.

- If existing spaces are not appropriate for an ecological network, could they be improved, and if so, how?

This study has shown that fishponds and urban farms are significant patches in terms of their large area. Work in other places in Indonesia has shown how the fishpond could be improved through adopting silvo-fishery culture. Although has not been tried in Makassar, this could be a way for improving such spaces to have better ecological quality. Agriculture fields and patches of other typologies can also be improved, as illustrated in Chapter 10.

- In terms of open space how does the city link up with its adjacent areas?

As a growing city, Makassar is inseparable from the areas in its proximity, which are the three adjoining regencies. The government has acknowledged this through establishing an integrated development area called "Mamminasata', the area in this study described as the 'greater urban region'. This study looked at the land use and character of the regions outside the main city, concluding the existing landscape matrix shows it would be possible to link a network of green spaces in Makassar ('the most preferred spaces') to the wider region and to areas of high ecological value, formed by the two National parks. In this context useful spaces for creating this linkage are forests of various types, more natural agriculture fields and farms/woods with scattered settlements. The layout of these spaces in relation to the main city is shown and described in Chapter 9.

11.2. What can be learnt from this study

The main method for green space assessment, which involved fieldwork activities, is the Rapid Biodiversity Assessment (RBA). This method was chosen having considered its practicability and applicability when resources and times are limited. The only thing that needs more articulation is whether the method was adaptable for developing and tropical conditions, considering that the method was developed in a developed, temperate country.

This study proved that with several adjustments to local condition the method was applicable. The adjustments were related to technical approaches and application, intensity of observation and the need to overcome the lack of preliminary data and information, such as a list of plants found in the study location. With the latter and the adjustments made for this study (see Chapter 6), this method can be carried out successfully. However, having performed this assessment on various shapes of patch, this study highlights the importance of finding methods for assessing narrow linear patches as well as corridors, as these are often the types of space found in cities.

It is important to understand that apart from a basic land use map and government inventory green spaces data, this study started with a lack of information and knowledge about the relevant context of the study location. Therefore, the efforts and stages shown in this study to try and translate information from elsewhere, along with the adaptation of the assessment method, could be further developed into a technical to-do list. Such a list might be useful for conducting similar studies in other Indonesian cities, and even further afield to other developing cities in tropical locations.

One significant parameter for assessing the quality of spaces as habitat is the extent of native vegetation. The plant biodiversity assessment used in this study did not distinguish between native and exotic plants, which is a potential weakness of the study. A combined approach that assesses both general plant biodiversity and vegetation status would strengthen the results of such assessment. This is important to consider for future research.

One important finding of this study is the importance of corporate and private spaces as part of the total available green space area in the city. Relying only on limited public and state land means the implementation of any form of network of green spaces will not be possible. Unfortunately, despite private green space being mentioned as an important part of urban green space in government regulations, there is no arrangement or agreement known between the authorities and private parties in any city in Indonesia. This could be a potential area for further research, in order to determine whether the inclusion of private spaces in government managed green spaces in urban areas is possible.

Assessment of a network and connectivity between spaces can be further performed using a more quantitative method (Aminzadeh & Khansefid, 2010; Cook, 2002; Rudd et al., 2002; Uy & Nakagoshi, 2007). This Makassar study has limitations in terms of relevant data and information, such as that concerning existing target species and patches, as well as limitations in the resources and tools available to perform such a detailed assessment. This again forms an area for further research building on the work in this thesis.

11.3. Recommendations

A greenway, green network, or an ecological network, can only be implemented in Makassar if certain aspects for improvement are taken into consideration. These aspects are listed below.

1. The significance of creating a typology is that it shows the type of areas that dominate the landscape of the city. It then becomes important to consider improving their quality to meet the requirements for making them viable patches of an ecological network. For Makassar, the two most significant features are urban farms and fish ponds. The importance of these cultural fields is not only their socio-economic benefits but also their potential environmental benefits. This study shows that both these areas could be improved in terms of their ecological quality. In Makassar it is also important to consider other strong patches such as urban forests.
2. The study shows the importance of the utilization of non-public spaces and non-state land, both of which have great potential for becoming ecological patches or even corridors. Importantly, the government needs to consider private spaces as these contribute greatly to the total open area and green spaces in the city. Their inclusion into a government program for some form of ecological concept and

network is essential. Not only will their inclusion help the city to meet urban green space standards, but they could also be part of green network. Hence it is important for the government to consider arrangements with the private sector or individual owners for their participation.

3. Any remnants of nature in the city have definite potential for becoming ecological spots, therefore it is necessary to preserve and improve whatever remains in as natural a state as possible.
4. An ecological network relies on good ecological patches with buffer areas protecting the core areas. When it is not possible to find features of such quality within the main city, it is essential to find such patches out of the main city in more rural landscapes and link these up to spaces in the main city by utilizing other supporting patches and corridors. For the case of Makassar, the inclusion of the greater urban region (Mamminasata) makes an ecological network more feasible by seeing the National parks and wildlife reserves as the main ecological source. Integration of a green network for the main city area (Makassar) with a network of patches and corridors of ecological value in the outer suburbs could produce the opportunity for species to migrate into the city from the richer ecological network of the surrounding region. This would be the ideal outcome of the implementation of some form of ecological network. In other words, an ecological network is possible for Makassar as part of a greater urban region network, including the three adjoining regencies.
5. It is important to ensure that any green or ecological network for the city is backed up by proper enforced policy and regulation. This could be a challenging task, but is necessary to encourage the supporting behaviour and attitudes of the people. This will require prominent leadership by the authority, such as shown in the profound changes within Curitiba city (Macedo, 2004; Taniguchi, 1995).

11.4. Information for local government

This study provides useful information for the local government in terms of the potential the city has for the implementation of a network of green spaces or even an ecological network. This is not to say there will necessarily be implementation of such a network in the near future, since a level of improvement and effort is necessary to achieve spaces with qualities for being an ecological patch. Yet, with information of the type provided in this study, the local government will know where to start and which spaces they need to investigate further.

The results of this study should also be seen as useful in providing suggestions of where development should take place and which spaces should to be preserved as green or ecological spaces, by giving priority to keeping spaces with ecological value or potential. This study does not suggest all identified open and green spaces are to be preserved, rather it gives clues for establishing priorities by showing which spaces can be developed for other uses and which spaces should be maintained green and connected to other spaces in a network.

This study could also be useful in terms of helping the authority to set up either a short or long term target project for development of a green network. For example, roads within Makassar could have an important role as part of a green circuit to link other the available potential spaces, and hence there is a need to preserve or even improve their quality as ‘green’ corridors at certain points.

Apart from providing information regarding the potential spaces of the city, reflection on the results of this study might be useful for government in terms of patterns of development and patterns of space fragmentation, especially regarding natural river corridors and the state of cultural fields in the city.

Improvement in the densely populated area or the most urbanized part of the city should be approached by making use of whatever patches and corridors are available in the area. This is due to the fact they are actually ‘very close’ and could possibly be connected with the ‘preferred spaces’. In this sense roads and inter-house spaces become important to consider.

Concerning the corridors along the main river in the city (Tallo River) as the only natural remnant, and in relation with the long term plan for the projected development of the river for water transport and as a tourist attraction, this study suggests the government should be concerned about the function of the river as an important natural corridor. Instead of making the current fragmentation worse, the development project should strengthen the river function as a corridor. Development plans for the river as a tourist attraction are not necessarily detrimental for ecology as long as they are done carefully. On the other hand, planning for industrial sites near river corridors would be negative for the urban ecology.

The stages of this study, which started assessment from the site level, which in turn led to further regional scale analysis, provides a good indication of the importance of a bottom-up approach in performing assessment, even for something which could potentially have a bigger impact. The understanding of real potential as approached in this study can be followed by top down policy addressing the issues for implementation.

There are strategies that the city government should consider. First, the government must want the inclusion of an ecology-based concept in the city, and this should be reflected in the policies and regulations they make. Secondly, they must have good knowledge of all potential spaces in the urban area, including non-public and non-state land. Finally, with this knowledge they should produce spatial planning that complies with the appropriate ecology based concept. Although performed in Makassar, these assessment procedures should be applicable to other Indonesian cities as well as cities in other developing nations.

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Appendix 1. Sample of a completed field record sheet

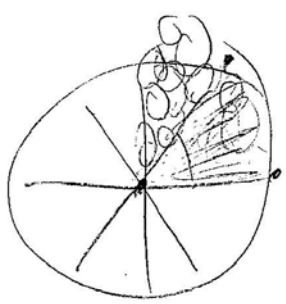
No lembar	[illegible]
Hari/Tanggal	Kamis / 13/07/2011
Waktu	09.00
Nama surveyor	Abu Bakar, Edi, Julian, Ilham
Kelas typology	Institutional space
Lokasi	Unhas
No titik sampling	04
Koordinat titk sampling	

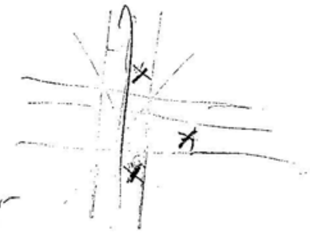
Struktur vegetasi	Tinggi tanaman	Nilai Dominasi									
		1	2	3	4	5	6	7	8	9	10
Pohon tinggi	≥ 10 m				1✓						
Pohon rendah	5 - ≤ 10 m										
Semak/perdu	1 - ≤ 5 m					✓					
Rumput tinggi	20 cm - ≤ 1 m					✓					
Rumput rendah	5 cm - ≤ 20 cm										2✓
Penutup tanah	≤ 5 cm						✓				
Tanaman air											
Daerah terbangun					✓						

Nilai dominasi=

1= <4% penutupan dengan jumlah individu sedikit;
2= <4% dengan jumlah individu sedang;
3= <4% dengan jumlah individu banyak;
4= 4-10%;
5= 11-25%;
6= 26-33%;
7= 34-50%;
8= 51-75%;
9= 76-90%;
10= 91-100%

12,5





12,5

6

UNHAS 04

Pengamatan genera tanaman vaskular

No	Jenis/genus tanaman	Transek I	Transek II	Transek III	Transek IV
1	Rumput [illegible] (4273)				
2	Putri Malu				
3	(4274)				
4	(4275)				
5	(4276)				
6	Imperata cylindrica (4277)				
7	pohon (4278)				
8	(4279)				
9	Nangka (4280)				
10	rumput (4281)				
11	Amaranthus spinosus (4282)				
12	tebu (4283)				
13	(4284)				
14	(4285)				
15	(4286)				
16	(4287)				
17	(4291)				
18	Bauhinia (4292)				
19	Agave (4293)				
20	Alocacea (4295)				
21	(4296)				
22	Pohon (4297)				
23	~~Ketapang~~ Flamboyan				
24	Jati				
25	(4298)				
26	(4299)				
27	Bunga [illegible] (4300)				
28	Mangga				
29	(4301)				
30	Ubi kayu				
31	[illegible] (4302)				
32	(4304)				
LM 33	Pohon (4305)				
34	Palm (4306)				
35	(4307)				

36 (4308)

37 Pepaya

38. (4309)

39. Lontar

40 (4310)

41 (4311)

Appendix 2. Scoring procedure

The procedure combines structural elements and diversity of vascular plant into a biodiversity score

Step 1: For each structure of vegetation found:	
+ 1 point (regardless of the dominant coverage scale (Domin value) of each structural element)	
Step 2: Additional points with reference to the Domin value of the dominance value of built layer	
-1 point for built layer Domin value 6	+1 point for built layer Domin value 5
-2 point for built layer Domin value 7	+2 point for built layer Domin value 4
-3 point for built layer Domin value 8	+3 point for built layer Domin value 3
-4 point for built layer Domin value 9	+4 point for built layer Domin value 2
-5 point for built layer Domin value 10	+5 point for built layer Domin value 1
Step 3: Additional points with reference to the number of vascular plants species	
+1 point for every 6 plant species identified to be dominant in the sampling location	
+0 point for no vascular plants present	+4 points for 19 - 24 species found
+1 point for ≤ 6 species found	+5 points for 25 - 30 species found
+2 points for 7 - 12 species found	+6 points for 31 - 36 species found
+3 points for 13 - 18 species found	+7 points for 37 - 42 species found (and so on)
Step 4: Sum final biodiversity score	
Sum the scores resulting from steps 1 to 3	

Appendix 3. Standard deviation analysis

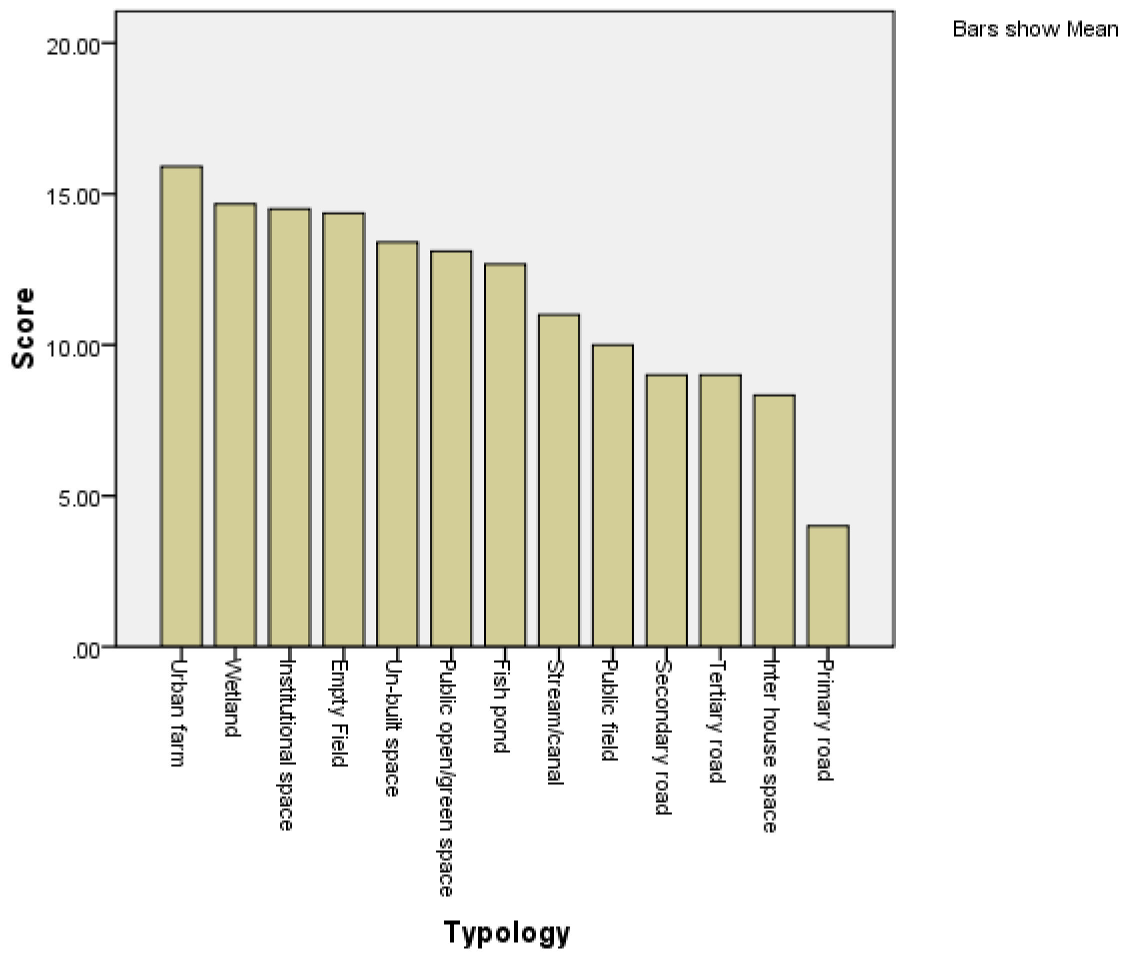
Analysis result with statistical software (SPSS version 14.0):

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean		Std. Dev	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Score	13	11.91	4.00	15.91	11.5338	.93198	3.36030	11.292	-.835	.616	.441	1.191
Valid N (listwise)	13											

Classification

1. Low ➔ average value – 0.5 times deviation std value = 11.5338 – (0.5 x 3.36030) = 9.85365
2. High ➔ average value + 0.5 times deviation std value = 11.5338 + (0.5 x 3.36030) = 13.21395
3. Medium ➔ <u>from</u> > average value – 0.5 times deviation std value <u>to</u> < average value + 0.5 times deviation std value



Statistics

		typology	score
N	Valid	13	13
	Missing	0	0
Mean			11.5338
Std. Error of Mean			.93198
Median			12.6700
Mode			9.00
Std. Deviation			**3.36030**
Variance			11.292
Skewness			-.835
Std. Error of Skewness			.616
Kurtosis			.441
Std. Error of Kurtosis			1.191
Range			11.91
Minimum			4.00
Maximum			15.91
Percentiles	25		9.0000
	50		12.6700
	75		14.4300

Frequency Table

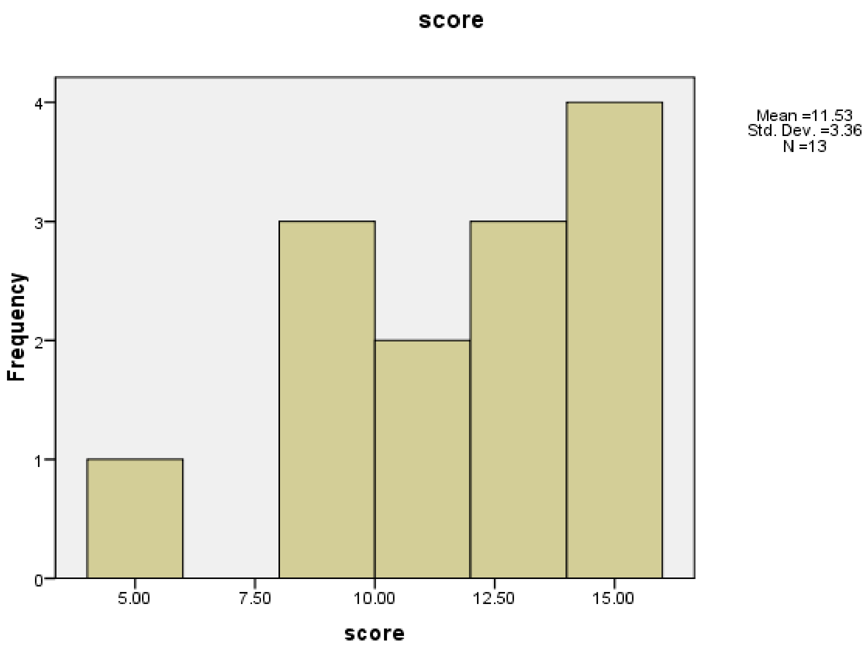
typology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Empty Field	1	7.7	7.7	7.7
	Fish pond	1	7.7	7.7	15.4
	Institutional space	1	7.7	7.7	23.1
	Inter house space	1	7.7	7.7	30.8
	Primary road	1	7.7	7.7	38.5
	Public field	1	7.7	7.7	46.2
	Public open/green sp	1	7.7	7.7	53.8
	Secondary road	1	7.7	7.7	61.5
	Stream/canal	1	7.7	7.7	69.2
	Tertiary road	1	7.7	7.7	76.9
	Un-built space	1	7.7	7.7	84.6
	Urban farm	1	7.7	7.7	92.3
	Wetland	1	7.7	7.7	100.0
	Total	13	100.0	100.0	

Score

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4	1	7.7	7.7	7.7
	8.33	1	7.7	7.7	15.4
	9	2	15.4	15.4	30.8
	10	1	7.7	7.7	38.5
	11	1	7.7	7.7	46.2
	12.67	1	7.7	7.7	53.8
	13.1	1	7.7	7.7	61.5
	13.4	1	7.7	7.7	69.2
	14.36	1	7.7	7.7	76.9
	14.5	1	7.7	7.7	84.6
	14.67	1	7.7	7.7	92.3
	15.91	1	7.7	7.7	100.0
	Total	13	100.0	100.0	

Distribution of score frequency



Interpretation of analysis of descriptive statistical analysis (frequency and descriptive)

- The amount of data that is processed (N) is 13 and everything is valid, nothing is missing
- The mean value is 11.5338 with guilt deviation (standard error of mean) of 3.36030
- The median value is 12.67 meaning that after sorting the data (ascending or descending), the value of the data at the centre of data row (in this case between the 6th and 8th) is equal to 12.67.
- Mode value is 9.00, meaning the most frequent value is 9.00
- Standard deviation is 3.36030. The smaller the standard deviation, the more homogeneous the data within the variable. The squared value of 3.36030 equals the value of variety (variance).
- Symmetry (inclination) of the data distribution is determined by the value of skewness. The typology data has skewness value of -0.835 (negative) which means the peak of the curve is slightly sloping near normal (see distribution of score frequency graph above).
- The fineness of distribution curve is indicated by the value of kurtosis (0.441), which means the peak of typology data distribution curve is on the right of the average value, sticking to the left (see frequency distribution graph).
- Normality of the distribution curve can be determined by the ratio value of skewness (Rs) and kurtosis ratio (Rk). It can be calculated from data in the table: Rs = -0.835/0.616 = -1.3555 and Rk = .0.441/1.191 = 0.370. From these values it can be concluded that the distribution curve is statistically within the normal distribution because the value is between - 2 and + 2.
- Range value is 11.91, which is the result of the subtraction of the maximum (15.91) and the minimum (4.00).
- If all data are sorted and divided by a hundred of equal groups, then the typology value finished 25^{th} (to 25 percent) is 9.000, the value of the 50^{th} (to 50 percent, equal to the median) is 12.6700 and the value which finished 75th (to 75 percent) is 14.4300.
- In other words: values around 25% can be classified as low, values around 50% as medium and values around 75% as high

Appendix 4. List of identified vascular plants

Notes for appendices 5 and 6:

Typology Code:

IH = Inter-house space	**CS** = Commercial space	**US** = Un-built space
EF = Empty field	**IS** = Institutional space	**PF** = Public field
OS = Public open/green space	**WL** = Wetland	**FP** = Fish pond
UF = Urban farm	**PR** = Primary road corridor	**SR** = Secondary road corridor
TR = Tertiary road corridor	**RC** = River corridor	**SC** = Stream/canal corridor
IP = In-property corridor		

Location Code:

01	Bumi Tamalanrea Permai (BTP) and its surrounding	02	Bukit Baruga	03	Villa Mutiara
04	Mappaodang	05	University of Hasanuddin	06	Gedung Juang 45
07	Governor’s Office	08	Al Markaz Al Islami	09	A space at Urip Sumoharjo (behind finance bld)
10	Borong	11	Baddoka	12	Karebosi
13	Dg. Tata	14	Baddoka Golf Course	15	Panaikang cemetery
16	Taman Macan	17	Teuku Umar fishing lake	18	Kera-kera
19	Metro Tanjung Bunga	20	Sutarmi highway	21	Wetland at Borong
22	Minasa Upa	23	Panakkukang	24	Teuku Umar
25	Adyaksa	26	Antang	27	Pettarani street
28	Boulevard street	29	Dg. Sirua street		

Appendix 4. Continued.

No	Botanic Name	Local Name	English / Common Name	Structure / Habitus	Topology of Space	Location
1	*Acacia auriculiformis*	Akasia	Earleaf acacia	tree	UF, OS, WL, IS	08, 09, 11, 15, 16, 17
2	*Acacia podalyriifolia*	Akasia	Pearl acacia	tree	OS, IS	08, 11, 15
3	*Acalypha indica*	Kucing-kucingan	Indian nettle	ground flora	IS	05, 01
4	*Achyranthes aspera*	Jarong lalaki	Devil's horsewhip	bush	IS	05
5	*Acrosticum aureum*	Paku laut	Golden leather fern	ground flora	OS	02
6	*Adenium sp*	Kamboja	Desert roses	low bush	TR	02
7	*Adiantum sp*	Suplir	Maidenhair	bush	IS, IH	02, 05
8	*Aegle marmelos*	Maja	Bael fruit	tree	EF, OS	01, 02
9	*Agave americana*	Agave amerika	Century plant	succulent/bush	IS	05
10	*Agave sp*	Agave/siklok	American aloe	succulent	OS, IS	07, 08, 16
11	*Ageratum conyzoides*	Bandotan	Chick weed	ground flora	EF	13
12	*Aglaia odorata*	Daun pacar	Chinese rice flower	bush	EF	13
13	*Alpinia sp*	Lengkuas	Red ginger	ground flora	EF, SC	25, 29
14	*Alternanthera amoena*	Bayam merah	-	bush	UF, OS, TR, SC	02, 03, 09, 16, 29
15	*Amaranthus sp*	Bayam	Spinach	bush	UF	10
16	*Amaranthus spinosus*	Bayam duri	Spiny Amaranthus	bush	EF, IS, FP	01, 05, 18
17	*Amorphophallus sp*	Bunga Bangkai	-	shrub	OS, IS	02., 05, 09
18	*Anacardium occidentale*	Jambu mente	Cashew nut	tree	IH, US	04
19	*Ananas comosus*	Nanas	Pineapple	succulent/shrub	TR, US, IS	03, 05
20	*Annona muricata*	Sirsak	Soursop	tree	IS	05
21	*Annona squamosa*	Sri kaya	Sarikaya, atis	tree	EF, UF, IH, IS, PF OS, SR, US, WL	01, 04, 05, 06, 09, 10, 12, 15, 25, 29
22	*Anthurium sp*	Kuping gajah	Flamingo lily	bush	IH	01
23	*Araucaria exelsa*	Cemara Norfolk	Norfolk Island pine	tree	IS, TR	02, 07
24	*Artocarpus communis*	Sukun	Breadfruit	tree	EF, OS, IS, TR	01, 02, 07, 09

No	***Botanic Name***	**Local Name**	**English / Common Name**	**Structure / Habitus**	**Topology of Space**	**Location**
25	*Artocarpus heterophyllus*	Nangka	Jack fruit	tree	UF, EF, IS, OS, SR, TR, IS	01, 02, 05, 06, 07, 09, 16, 29
26	*Arundina graminifolia*	Anggrek tanah	Bamboo orchid	low bush	OS, IS	05, 16
27	*Asplenium sp*	Paku-pakuan	Ferns	ground flora	IH, OS, IS, WL	04, 05, 10, 16
28	*Averrhoa bilimbi*	Belimbing	Cucumber tree	tree	UF, IS, OS, TR, SR, WL	01, 02, 04, 05, 09, 29
29	*Averrhoa pentandra*	Belimbing Buah	Star fruit	tree	TR	02
30	*Axonopus compressus*	Rumput Peking	Broad-leaved carpetgrass	low grass	IS, EF, US	03, 05, 13
31	*Bambusa sp*	Bambu	Bamboo	high bush	EF, UF, IH, OS, SR, US, IS	01, 02, 03, 04, 05, 09, 25, 29
32	*Bambusa sp*	Bambu Kuning	Yellow bamboo	bush	IS	07
33	*Bauhinia purpurea*	Bunga kupu-kupu ungu	Purple Orchid-Tree	tree	OS, IS	08, 16
34	*Bauhinia tomentosa*	Bunga kupu-kupu kuning	Yellow Bell Orchid Tree	tree	SR	29
35	*Bidens pilosa*	Ajeran, ketul	Cobblers pegs	ground flora	IS	05, 07
36	*Blumea balsamifera*	‘sembung’ (Javanese)	Ngai camphor	ground flora	IS, EF	05, 25
37	*Dendrobium crumenatum*	Anggrek merpati	Pigeon Orchid	ephiphyte	SR	29
38	*Syzygium malaccense*	Jambu Ball	Malay apple	tree	UF	09
39	*Lamnea grandis*	Tammate' , kayu Jawa	-	tree	UF, EF, OS, US, IS	01, 03, 09, 11, 25
40	*Borassus flabellifer*	Lontar	Wine palm	tree	UF, EF, US, OS, IS	04, 05, 06, 07, 08, 09, 13, 16
41	*Boreria latifolia*	Bulu lutung		shrub	IS	05

No	*Botanic Name*	Local Name	English / Common Name	Structure / Habitus	Topology of Space	Location
42	*Bougainvillea glabra*	Kembang kertas	Paper flower	bush	IS, OS, UF, IH, OS, TR, US	01, 02, 03, 05, 07, 09, 16
43	*Bougainvillea spectabilis*	Bugenvil	-	bush	IS	08
44	*Bromelia comosa*	Nanas Hias	Exotic pineapple	succulent/bush	TR, IS, OS	02, 05, 16
45	*Bromolia sp*	Bromelia	Bromeliad	succulent/bush	SR	29
46	*Bruguiera sp*	Bakau	Mangrove	water plant	EF	25
47	*Cajanus cajan*	Kacang gude	Pigeon pea	bush	UF	09
48	*Calopogonium mucunoides*	Kacang asu	Calopo	ground flora	IS, OS, EF	01, '02, 05
49	*Camptotheca sp*	Pohon bahagia	Happy tree	tree	SR	29
50	*Canna Sp.*	Bunga kana	Poloke	bush	UF, OS, WL, EF, IH	01, 09, 16
51	*Capsicum sp*	Cabe	Chili	bush	EF, IH, SC	01, 25, 29
52	*Carica papaya*	Pepaya	Papaya	tree	EF, US, IS, UF, IH, PF, OS, SR, TR, SC, WL	01, 02, 03, 04, 05, 06, 09, 12, 13, 17, 25, 29
53	*Caryota mitis*	Palem Ekor Ikan	Fish tail palm	tree	IS, OS	05, 07, 15
54	*Cassia florida*	Johar		tree	OS	16
55	*Cassia tora*	-	Foetid Cassia	tree	EF, IS	03, 05
56	*Catharanthus roseus*	Tapak dara	Madagascar periwinkle	ground flora	IS	05
57	*Ceiba petandra*	Kapuk	Kapok	tree	UF, EF, US, IS, WL	01, 03, 04, 05, 06, 09, 25
58	*Celosia cristata*	Jengger ayam	Cockscomb	bush	SC, IS	05, 29
59	*Centrocema pubescens*	Kakacangan	Centro	ground flora	IS, EF, US	01, 03, 05
60	*Chleoma viscose*	Mamang kuning	Tickweeed	ground flora	IS	05
61	*Chlorophytum comosum*	Lili paris	Spider plant	ground flora	OS, TR, US, IS	02, 03, 07, 16
62	*Chromolaena odorata*	Jonga-jonga, Kirinyuh	Jack in the bush	high grass	IS, EF	05, 23
63	*Chrysalidocarpus lutescens*	Palem Kuning	Yellow leaf palm	tree	OS, SR, IS	05, 16, 28

No	*Botanic Name*	Local Name	English / Common Name	Structure / Habitus	Topology of Space	Location
64	*Sida rhombifolia*	Sidaguri	Cuban jute	low bush	IS	05
65	*Citrus aurantifolia*	Jeruk nipis	Lime	tree	EF, IH, OS	04, 09, 25
66	*Citrus sp*	Jeruk	Orange/Lemon	tree	IH, OS, TR	01, 02, 15
67	*Cleoma rutidosperma*	Maman ungu	Fringed spiderflower	ground flora	IS, OS, EF	02, 05, 16
68	*Cocos nucifera*	Kelapa	Coconut	tree	UF, EF, IS, IH, OS, SR, TR, SC, US, WL	01, 02, 03, 04, 05, 06, 08, 09, 17, 25, 29
69	*Codiaeum variegatum*	Puring	Croton	bush	IH, OS, SR, TR, IS	01, 02, 03, 05, 07, 09, 16, 29
70	*Coleus atropurpureus*	Iler	Coleus	ground flora	SC	29
71	*Coleus sp*	Jawer kotok	Dwarf coleus	ground flora	IS	05
72	*Colocasia sp*	Talas	Taro	ground flora	UF, EF, IH, OS, SR, SC, IS, WL	01, 02, 04, 05, 06, 08, 09, 10, 25, 29
73	*Commelina benghalensis*	Gewor	Tropical spiderwort, dayflower	ground flora	IS	05
74	*Commelina diffusa*	Aur aur	Climbing dayflower	ground flora	IS	05
75	*Cordyline fruticosa*	Hangjuang	Hawaian ti	shrub	PF, EF, UF, IH, OS, IS	01, 02, 04, 05, 09, 12, 16, 25
76	*Cordyline terminalis*	Hanjuang	Ti tree	shrub	SR, TR, US, IS	01, 02, 03, 05, 29
77	*Crynum asiaticum*	Bakung	Crinum lily	shrub	IS	05
78	*Cucumis sativus*	Timun	Cucumber	creeping ground flora	UF	10
79	*Cucurbita sp*	Labu	Butternut squash	creeping ground flora	UF, EF, IH, IS	01, 04, 05, 06, 08, 10, 25
80	*Cupressus sempervirens*	Cemara	-		OS	15, 16

No	*Botanic Name*	Local Name	English / Common Name	Structure / Habitus	Topology of Space	Location
81	*Curcuma sp*	Kunyit	Curcuma	rhizome	EF	25
82	*Cymbopogon sp*	Serai	Citronella grass	grass	UF, EF, SR, TR, SC, UF, IS	02, 03, 05, 09, 25, 29
83	*Cyperus rotundus*	Rumput Teki	Nut grass	grass	UF, EF, IS, IH, OS, SR, SC, US, WL	04, 05, 06, 08, 10, 13, 16, 17, 25, 29
84	*Cyrtostachys lakka*	Palem merah	Red palm	tree	IH, OS, SR, TR	02, 04, 16, 29
85	*Delonix regia*	Flamboyan	-	tree	UF, IH, OS, TR, US, IS	01, 03, 05, 07, 09, 11, 15, 16
86	*Desmodium triflorum*	Sisik betok	Three-flowered beggarweed	ground flora	IS	05
87	*Dieffenbachia sp*	Bunga bahagia	Dieffenbachia, dumbcane	bush	OS, SR, IS	03, 05, 09, 29
88	*Dracaena sanderiana*	Bambu Sri Rejeki	Ribbon plant	bush	OS	09
89	*Dracaena surculosa*	Bambu Jepang	Gold dust dracaena	bush	OS, SR	05, 29
90	*Duranta erecta*	Pangkas Kuning	Golden dewdrop, pigeonberry	bush	PF, TR	02, 12
91	*Duranta repens*	Pangkas Hijau	Sapphire Showers	bush	OS	02, 16
92	*Eichornia crassipes*	Eceng gondok	Water hyacinth	water plant	WL, UF, EF	01, 09, 10, 17, 25
93	*Elaeis oleifera*	Kelapa Sawit	Oil palm	tree	OS, IS	02, 07, 08, 16
94	*Elephantophus tomentosus*	Tapak liman	Devil's grandmother	ground flora	IS	05
95	*Elephantopus scaber*	Dila-dila	-	ground flora	IS, FP	05, 20
96	*Eleusin indica*	Rumput belulang	Goose grass, bullgrass	grass	IS, US, EF	01, 05, 24
97	*Eugenia aquea*	Jambu air	Water Cherry, Watery Rose Apple	tree	EF, IH, OS, US, TR	01, 02, 04, 25
98	*Euphorbia heterophylla*	Patikan kebo	Desert poinsettia	ground cover	IS	05
99	*Euphorbia hirta*	Gelang susu	Hairy spunge	ground cover	IS	05
100	*Ficus benjamina*	Beringin	Weeping fig	tree	UF, IH, EF, OS, TR, SR, IS	01, 02, 04, 05, 06, 07, 09, 13, 16, 29

No	*Botanic Name*	Local Name	English / Common Name	Structure / Habitus	Topology of Space	Location
101	*Gliricidia sp*	Gamal	-	tree	UF, EF, IH, OS, SR, US, IS	01, 02, 03, 04, 05, 09, 11, 15, 29
102	*Gmelina arborea*	Jati	White teak	tree	IS, EF, IH, SR	01, 05, 07, 11, 29
103	*Heliconia sp*	Pisang Hias	Heliconia	bush	TR, IS	02, 05
104	*Hibiscus macrophyllus*	Waru	Largeleaf rosemallow	tree	EF, WL, UF, IH, OS, IS	01, 02, 04, 07, 09, 16, 17, 25
105	*Hibiscus rosa-sinensis*	Kembang sepatu	Rose mallow	bush	EF, TR, US, IS	02, 03, 05, 07, 25
106	*Hylocereus undatus*	Buah Naga	Dragon fruit	bush	TR	02
107	*Hyophorbe lagenicaulis*	Palem botol	Bottle palm	tree	IH, TR	01, 02
108	*Hyptis capitata*	Rumput knob	Ironwort	ground flora	IS	05
109	*Imperata cylindrica*	Alang-alang	Blady grass	low grass	IS, WL, EF, US	01, 03, 05, 06, 08, 10, 13, 25
110	*Ipomoea aquatica*	Kangkung	Water morning glory	Water plant	UF, SC, IS, WL	05, 09, 10, 17, 29
111	*Ipomoea pestigridis*	Gamet' (Javanese)	Tigers Foot morning glory	ground flora	IS	05
112	*Ipomoea reptana*	Kangkung liar	Garden morning glory	ground flora	UF, EF, IS	01, 02, 05, 10, 25
113	*Ipomoea triloba*	-	Littlebell	ground flora	IS	05
114	*Ipomoea batatas*	Ubi jalar	Sweet potato	creeping ground flora	UF, EF, SR, SC, US, WL	01, 06, 09, 10, 29
115	*Ipomoea pes-caprae*	Tapak kuda	Beach morning glory	ground flora	EF	13
116	*Iresine herbstii*	Daun miana	Herbst's bloodleaf	bush	IS, SR	05, 29
117	*Ixora sp*	Asoka	Jungle flame, needle flower	bush	IH, OS, SR, TR, US, IS	01, 02, 03, 04, 09, 16, 28, 29
118	*Jatropha curcas*	Jarak pagar	Barbados nut	tree	UF, EF, IH, OS, IS, SR, TR	01, 02, 05, 15, 25, 29
119	*Jatropha sp*	Jarak	Coral plant	tree	UF, EF, OS	09, 15, 25
120	*Justicia gendarussa*	Gandarosa	Willow-leaved justicia	bush	PR, SR, TR, UF, PF, OS, IS	02, 03, 05, 09, 11, 12, 27, 28, 29
121	*Justicia sp*	Gandarusa putih		bush	IH, OS, US	01, 02, 03, 16

No	*Botanic Name*	Local Name	English / Common Name	Structure / Habitus	Topology of Space	Location
122	*Kleinhovia hospita*	Paliasa, Timongo'	Guest tree	tree	IH, IS, OS	04, 05, 16
123	*Lagerstroemia speciosa*	Bungor	Banaba	tree	IS	05
124	*Lantana camara*	Tahi ayam	Lantana	ground flora, bush	OS, SR, IS	05, 07, 15, 29
125	*Leucaena leucocephala*	Petai Cina	Lead tree	tree	UF, IH, IS	04, 07, 09, 10
126	*Leucaena sp*	Lamtoro	Lead tree	tree	UF, EF, SR, SC, US, IS	01, 02, 03, 05, 11, 25, 29
127	*Livistona sp*	Palm kipas	-	bush	OS, SR	06, 28
128	*Mangifera indica*	Mangga	Mango	tree	UF, EF, IH, IS, OS, SR, TR, SC, US, WL	01, 02, 03, 04, 05, 06, 07, 09, 10, 11, 17, 25, 29
129	*Manihot utillisima*	Singkong	Cassava	shrub	OS, EF, UF, IH, SR, TR, SC, US, IS, WL	01, 02, 03, 04, 05, 06, 09, 10, 17, 25, 29
130	*Mimosa invisa*	Putri malu besar	-	low bush	IS	05
131	*Mimosa pudica*	Putri malu	Shy plant, puahilahila	ground flora	IS, EF, UF, IH, OS, TR, US, WL	01, 02, 03, 04, 05, 07, 08, 09, 10, 11, 13, 17, 25
132	*Mimusops elengi*	Tanjung	Spanish Cherry	tree	EF, PF, OS, PR, SR, TR, US, IS	02, 03, 04, 05, 06, 07, 08, 12, 15, 16, 27, 28, 29
133	*Morinda citrifolia*	Mengkudu	Noni	tree	UF, EF, IH, OS, SR, TR, US, WL, IS	01, 02, 03, 04, 05, 06, 07, 09, 10, 11, 17, 25, 29
134	*Moringa oleifera*	Kelor	Moringa	bush	UF, EF, IH, OS, TR, SC	01, 02, 06, 09, 15, 25, 29
135	*Mucuna sp*	Kacang koas	Velvetbean	bush	IS	05
136	*Muntingia calabura*	Kersen	Jamaica Cherry	tree	EF, UF, US, SR	04, 06, 10, 25, 29
137	*Musa sp*	Pisang	Banana	tree	UF, EF, IH, OS, PR, SR, TR, US, IS, WL,	01, 02, 03, 04, 05, 06, 07, 09, 10, 13, 17, 25, 27, 29
138	*Nephelium lappaceum*	Rambutan	Rambutan	tree	IH, OS, SR	01, 02, 04, 29
139	*Neprolepis exaltata*	Pakis Kelabang	Centipede fern	ground flora	OS	16
140	*Nypa fruticans*	Nipa/ Nipah	Nipa palm	tree	EF, fish pond, OS	02, 18, 25
141	*Ocimum sanctum*	Kemangi	Holy basil	Ground flora	EF	25

No	*Botanic Name*	Local Name	English / Common Name	Structure / Habitus	Topology of Space	Location
142	*Opuntia sp*	Kaktus	Cacti	succulent	IS	05, 11
143	*Oryza sativa*	Padi	Rice	grass	UF, EF	01, 02, 10
144	*Oxalis barrelieri*	Belimbing tanah	Lavender sorrel	ground flora	UF	09
145	*Oxalis corniculata*	Semanggi gunung	-	bush	SR	29
146	*Pandanus amaryllifolius*	Pandan Wangi	Fragrant pandan	grass/shrub	UF, EF, IH, SR, US, WL	04, 06, 09, 10, 29
147	*Pandanus sp*	Pandan	Screwpine	shrub	UF, EF, OS, SR	02, 09, 25, 29
148	*Panicum sp*	Millet kuning	Panic grass	grass	IS	05
149	*Paspalum conjugatum*	Jukut pahit	Buffalo grass	grass	IS	05
150	*Pedilanthus tithymaloides*	Patah tulang	Zigzag plant	low bush	TR, US, IS	02, 03, 05
151	*Pennisetum purpureum*	Rumput gajah	Herbe elephant	grass	EF	01, 05, 06
152	*Pennisetum purpureum schamach*	Rumput Gajah Mini	Mini herbe elephant	grass	EF, OS, IS	05, '07, 13, 16
153	*Phaseolus sp*	Kacang pendek	Wild bean	bush	UF, WL	10, 17
154	*Pinus sp*	Pinus	Pine tree	tree	OS	02
155	*Piper sp*	Sirih	Pepper	climber plant	UF, EF	06, 09
156	*Platycerium sp*	Simbar (paku simbar)	Staghorn	ephiphyte	IS	05
157	*Plumeria acuminata*	Kamboja Besar	Temple tree	tree	OS, IH, TR	01, 02
158	*Plumeria sp*	Kamboja	Frangipani	tree	OS	15, 16
159	*Poligonum barbatum*	Jukut carang' (Sundanese) , 'salah nyowo' (Jawa)	Jointweed	grass	IS	05
160	*Polyalthia longifolia*	Glodogan Tiang	Ashoka tree	tree	PR, SR, OS, IS, OS, EF	01, 02, 05, 07, 11, 27, 29
161	*Polyalthia sp*	Glodokan biasa		tree	OS, IS	07, 15, 16
162	*Portulaca olerace*	Gelang biasa	Little Hogweed	ground flora	IS, WL	05, 19
163	*Portulaca sp*	Krokot	Common purslane	ground flora	OS	02

No	*Botanic Name*	Local Name	English / Common Name	Structure / Habitus	Topology of Space	Location
164	*Psidium guajava*	Jambu	Guava	tree	UF, EF, IH, PF, OS, US, SR, TR, IS	01, 02, 04, 05, 09, 13, 16, 25, 29
165	*Pteridium aquilinum*	Paku sarang burung	Eagle fern	ground flora	IS	05
166	*Pteridium sp*	Paku Pteridium	Common brackenfern	ground flora	IS	05
167	*Pterocarpus indicus*	Angsana	New Guinea Rosewood	tree	UF, EF, OS, IS, PR, SR, TR, SC	01, 02, 03, 05, 06, 09, 11, 16, 27, 29
168	*Rhaphidophora aurea*	Sirih gading		climber plant	IS	05
169	*Rhapis excelsa*	Palem Waregu	Broadleaf lady palm	bush	OS, TR, IS	02, 05, 16
170	*Rhoe discolor*	Adam Hawa	Oyster plant	ground flora	OS, TR, IS	02, 05
171	*Roystonea regia*	Palem raja	Royal palm	tree	IH, IS, PF, OS,	01, 04, 05, 07, 08, 12, 16
172	*Saccharum officinarum*	Tebu	Sugarcane	bush	UF, EF, OS, IS, WL	05, 06, 09, 10, 17, 25
173	*Salacca edulis*	Salak	Snake fruit	bush	IS, WL	05, 10
174	*Samanea saman*	Ki hujan	Rain tree	tree	UF, EF, PF, OS, SR, TR, SC, US, IS, WL	01, 02, 03, 05, 07, 08, 09, 12, 15, 16, 17, 27, 29
175	*Sansevieria trifasciata*	Lidah Mertua	Snake plant	ground flora/succulent	IS, IH, TR	02, 04, 05
176	*Sansievera sp*	Sansievera	Devil's tongue	ground flora/succulent	IH, OS, TR	01, 02, 04, 16
177	*Santalum album*	Cendana	Sandal wood	tree	SC	29
178	*Sida acuta*	Sidaguri	Common wireweed	bush	IS	05
179	*Solanum lycopersicum*	Tomat	Tomato	bush	UF, EF, IH, OS	01, 10, 25
180	*Solanum sp*	Terong	Egg plant	ground flora	EF, IH, SC, WL	01, 06, 17, 25, 29
181	*Solanum torvum*	Terung pipit	Turkey berry	bush	IS	05
182	*Spathodea campanulata*	Kecrutan	African tulip tree	tree	OS	16

No	*Botanic Name*	Local Name	English / Common Name	Structure / Habitus	Topology of Space	Location
183	*Spondias sp*	Kedondong	Ambarella	tree	OS, IS	05, 09
184	*Sporobolus sp*	Rumput strobulus	Dropseed	grass	IS, EF	05, 24
185	*Stachytarpheta jamaicensis*	Pecut kuda	Porterweed	grass	IS	05
186	*Swietenia mahagoni*	Mahoni	West Indian mahogany	tree	OS, SR	16, 29
187	*Synedrella nudiflora*	Jotang kuda	Cinderella weed	ground flora	IS	05
188	*Syzygium cumini*	Duwet, Coppeng	Java plum	tree	UF, EF, US	01, 02, 03, 25
189	*Tamarindus indica*	Asam	Tamarind	tree	EF, OS, IS, SR	01, 05, 16, 29
190	*Tectona grandis*	Jati	Teak wood	tree	EF, OS, IS, US, SR, TR	01, 02, 03, 05, 15, 29
191	*Terminalia sp*	Ketapang	Tropical almond	tree	UF, EF, IH, OS, SR, TR, SC, US, IS, WL	01,02, 03, 04, 05, 06, 08, 09, 16, 17, 25, 28, 29
192	*Theobroma cacao*	Cokelat	Cocoa	tree	OS	02
193	*Thuja orientalis*	Cemara kipas	-	tree	IS, PR, TR	02, 07, 27
194	*Tridax procumbens*	Songgolangit	Wild daisy	ground flora	IS	05
195	*Typha angustifolia*	Typha	Narrow leaf cat tail	Water plant	OS	16
196	*Veitchia merillii*	Palem Putri	Christmas palm	tree	OS, PR, TR, US, IS, UF	02, 03, 05, 07, 08, 09, 16, 27
197	*Vigna sinensis*	Kacang panjang	Long bean	bush	UF	02
198	*Voacanga grandifolia*	'cembirit' (Javanese)	Rolfe	low bush	IS	05
199	*Wedelia trilobata*	Wedelia	Creeping daisy	creeping ground flora	SR, SC	29
200	*Wodyetia bifurcata*	Palem Ekor Tupai	Squirrel tail palm	tree	OS, PR, TR, IS	01, 02, 03, 08, 16, 27
201	*Zea mays*	Jagung	Corn	bush	UF, EF, US, IS	01, 08, 10
202	*Zingiber officinale*	Jahe	Ginger	rhizome	SC	29
203	*Zoysia matrella*	Rumput Manila	Manila grass	grass	PF, OS	07, 12

Appendix 5. Sample of unrecognised vascular plants – plants from only three typologies of space

Note for Appendix 6:

Plant photograph		
a	b	c

a : Plant code
b : Typology of space where the plant was identified
c : Location code where the plant was identified

06 SC 29

07 SC 29

3205 US 01

3207 US 01

3208 US 01

3213 US 01

3214 US 01

3215 US 01

3218 US 01


01 SC 29


6024 US 03


6025 US 03


6027 US 03


6028 US 03


6029 US 03


14 US 04


19 US 04


6030 US 03


0064 US 03


0065 US 03


0066 US 03


0067 US 03


0068 US 03


0070 US 03


0071 US 03


0072 US 03


0073 US 03


6047 US 03


6049 US 03


6050 US 03


6051 US 03


6054 US 03


6056 US 03


6057 US 03


6058 US 03


11 US 04


13 US 04


5810 WL 10


5811 WL 10

09 WL 09

10 WL 09

13 WL 09

14 WL 09

10 WL 17

11 WL 17

19 WL 17

20 WL 17

21 WL 17

22 WL 17

24 WL 17

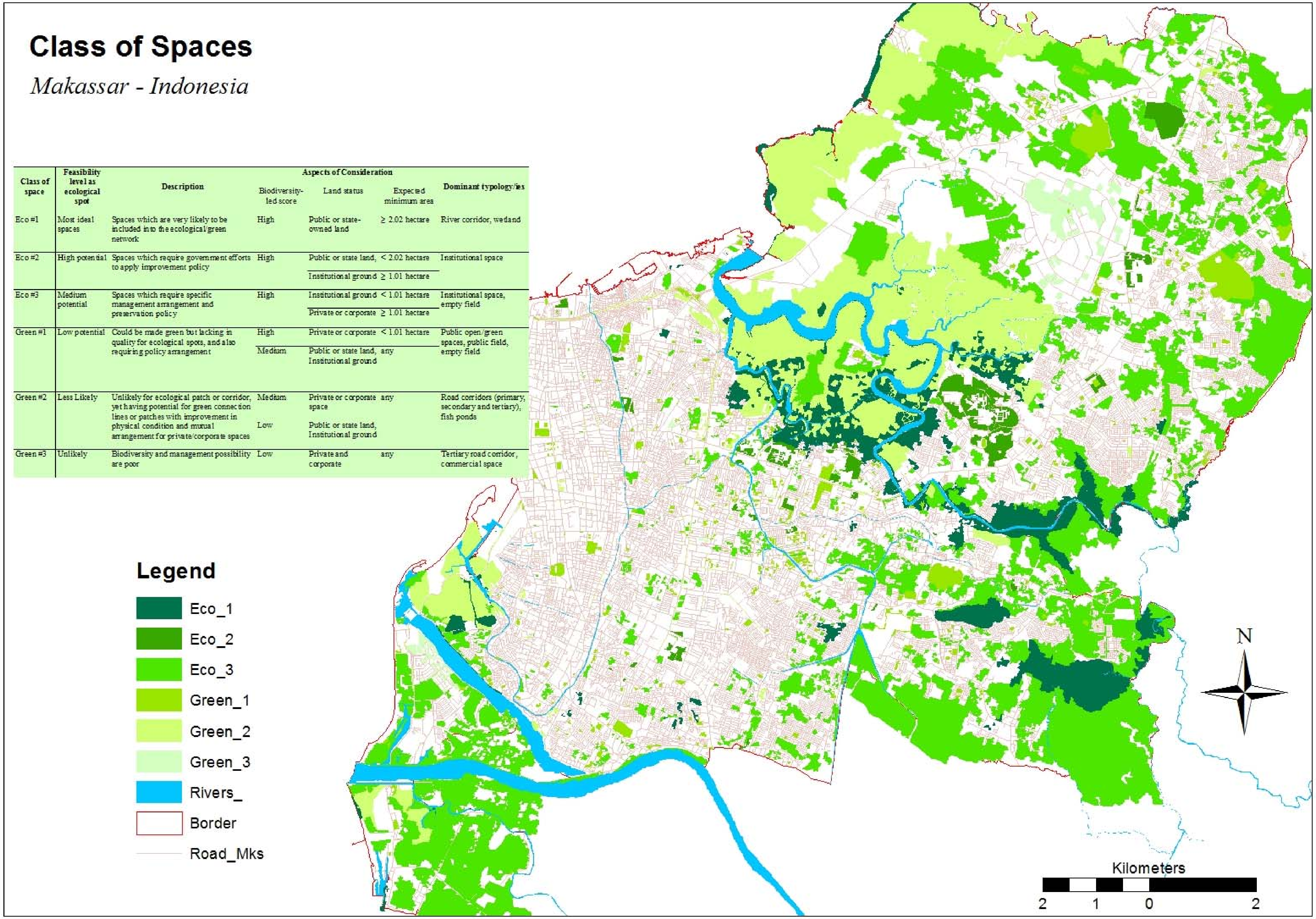
25 WL 17

26 WL 17

27 WL 17

28 WL 17

Appendix 6. Classes of space in Makassar based on three main considerations



Class of space	Feasibility level as ecological spot	Description	Aspects of Consideration: Biodiversity-led score	Land status	Expected minimum area	Dominant typology/ies
Eco #1	Most ideal spaces	Spaces which are very likely to be included into the ecological/green network	High	Public or state-owned land	≥ 2.02 hectare	River corridor, wetland
Eco #2	High potential	Spaces which require government efforts to apply improvement policy	High	Public or state land,	< 2.02 hectare	Institutional space
				Institutional ground	≥ 1.01 hectare	
Eco #3	Medium potential	Spaces which require specific management arrangement and preservation policy	High	Institutional ground	< 1.01 hectare	Institutional space, empty field
				Private or corporate	≥ 1.01 hectare	
Green #1	Low potential	Could be made green but lacking in quality for ecological spots, and also requiring policy arrangement	High	Private or corporate	< 1.01 hectare	Public open/green spaces, public field, empty field
			Medium	Public or state land, Institutional ground	any	
Green #2	Less Likely	Unlikely for ecological patch or corridor, yet having potential for green connection lines or patches with improvement in physical condition and mutual arrangement for private/corporate spaces	Medium	Private or corporate space	any	Road corridors (primary, secondary and tertiary), fish ponds
			Low	Public or state land, Institutional ground		
Green #3	Unlikely	Biodiversity and management possibility are poor	Low	Private and corporate	any	Tertiary road corridor, commercial space

Appendix 7. Vegetation structures of each sampling point

Location	Typology group	Sampling point	Biodiversity score	High Trees DV	Low Trees DV	Bushes DV	High Grass DV	Low Grasses DV	Ground Flora DV	Aquatic Flora DV	Built DV	No. of Vascular plants	No. of existing vegetation structure	Built structure existence	Vegetation structure without built area	Total Domination value of all vegetation structures excluding built areas
North of BTP	Empty field	01	18	1	1	7	3	7	2	1	1	27	8	Yes	7	22
BTP	Empty field	02	9	6	4	8	0	1	3	0	6	22	6	Yes	5	22
BTP	Empty field	03	7	4	2	4	0	1	1	0	8	20	6	Yes	5	12
BTP	Empty field	07	8	1	1	2	5	7	1	0	8	22	7	Yes	6	47
NHP	Empty field	09	16	5	3	8	2	1	1	0	0	27	6	No	6	43
Gedung Juang 45	Empty field	29	17	1	4	5	2	2	0	0	4	51	6	Yes	5	34
Dg. Tata	Empty field	45	13	9	7	9	6	8	6	0	6	39	7	Yes	6	17
Dg. Tata	Empty field	46	13	0	0	9	0	9	6	0	2	26	4	Yes	3	24
Teuku Umar	Empty field	64	16	9	7	7	4	4	3	0	2	26	7	Yes	6	20
Adyaksa	Empty field	65	21	7	6	6	6	6	6	6	1	45	8	Yes	7	45
Adyaksa	Empty field	66	20	8	7	7	7	6	7	5	1	42	8	Yes	7	14
Kera-kera	Fish pond	55	16	1	1	6	1	1	1	7	1	16	8	Yes	7	8
Metro Tanjung Bunga	Fish pond	56	11	0	0	2	2	1	1	5	0	6	5	No	5	11
Sutarmi highway	Fish pond	57	11	0	0	1	1	1	1	4	0	4	5	No	5	18
Telkomas	Institutional space	08	11	5	4	3	1	1	1	0	8	38	7	Yes	6	18
Hasanuddin University	Institutional space	22	18	5	1	9	7	7	5	0	1	35	7	Yes	6	26
Hasanuddin University	Institutional space	23	18	9	1	2	0	7	7	0	4	56	6	Yes	5	16
Hasanuddin University	Institutional space	24	12	9	8	6	8	0	0	0	8	59	5	Yes	4	33
Hasanuddin University	Institutional space	25	17	4	0	5	5	10	6	0	4	50	6	Yes	5	26
Hasanuddin University	Institutional space	26	14	8	7	1	0	10	1	0	4	35	6	Yes	5	25
Hasanuddin University	Institutional space	27	17	7	9	5	4	10	9	0	5	52	7	Yes	6	30
Hasanuddin University	Institutional space	28	17	7	6	4	0	9	4	0	8	82	6	Yes	5	15
Gedung Juang 45	Institutional space	30	16	2	4	4	3	7	5	0	3	33	7	Yes	6	44
Governor Office	Institutional space	31	14	9	7	6	0	9	2	0	4	36	6	Yes	5	27
Governor Office	Institutional space	32	13	9	1	1	1	2	2	0	4	22	7	Yes	6	30
Governor Office	Institutional space	33	9	4	7	4	0	6	5	0	5	12	6	Yes	5	31
Al Markaz	Institutional space	34	9	7	5	3	1	7	2	1	9	45	8	Yes	7	26
Al Markaz	Institutional space	35	18	2	4	3	1	6	2	0	1	32	7	Yes	6	34
BTP	Inter house space	05	4	1	1	2	0	1	1	0	10	15	6	Yes	5	28
BTP	Inter house space	06	8	1	1	4	0	1	5	0	10	40	6	Yes	5	12
Mappaodang	Inter house space	20	13	5	4	6	0	7	6	0	7	52	6	Yes	5	6
Bukit Baruga	Public open/green space	11	14	10	2	1	0	4	1	0	1	14	6	Yes	5	26
Bukit Baruga	Public open/green space	12	17	6	1	2	1	7	1	5	1	24	8	Yes	7	16
Bukit Baruga	Public open/green space	15	13	9	5	3	0	5	2	0	8	59	6	Yes	5	15
Urip Sumoharjo (behind finance bld)	Public open/green space	39	12	7	4	5	4	4	5	0	6	35	7	Yes	6	30

Baddoka Golf Course	Public open/green space	47	14	4	2	2	1	6	2	0	0	18	6	No	6	22
Baddoka Golf Course	Public open/green space	48	16	6	3	1	1	10	1	0	1	20	7	Yes	6	17
Baddoka Golf Course	Public open/green space	49	16	7	4	3	1	9	2	4	0	24	7	No	7	29
Panaikang cemetary	Public open/green space	50	8	5	4	2	1	2	1	0	9	25	7	Yes	6	24
Panaikang cemetary	Public open/green space	51	5	5	4	2	1	2	2	0	9	8	7	Yes	6	23
Taman macan	Public open/green space	52	16	8	4	7	0	5	1	1	7	66	7	Yes	6	18
Boulevard street	Secondary road	71	6	1	5	4	1	6	1	0	10	24	7	Yes	6	30
Dg. Sirua street	Secondary road	73	11	6	5	5	5	3	3	0	8	37	7	Yes	6	27
Dg. Sirua street	Secondary road	74	10	4	6	5	4	5	5	1	10	39	8	Yes	7	18
Bukit Baruga	Tertiary road	13	10	8	5	3	0	2	2	0	9	48	6	Yes	5	18
Villa Mutiara	Tertiary road	18	8	6	4	3	0	4	1	0	9	34	6	Yes	5	20
BTP	Un-built space	10	17	2	1	5	1	9	1	1	1	19	8	Yes	7	16
Villa Mutiara	Un-built space	16	14	5	4	7	1	9	1	0	5	33	7	Yes	6	15
Villa Mutiara	Un-built space	17	13	1	1	4	0	9	2	0	0	16	5	No	5	17
Villa Mutiara	Un-built space	19	14	2	1	1	0	10	1	0	1	17	6	Yes	5	27
Mappaodang	Un-built space	21	9	2	4	8	0	1	1	0	6	19	6	Yes	5	20
South of BTP	Urban farm	04	15	1	1	2	0	7	1	2	1	18	7	Yes	6	19
Bukit Baruga	Urban farm	14	17	1	1	2	6	7	0	1	2	34	7	Yes	6	22
Urip Sumoharjo (behind finance bld)	Urban farm	36	17	5	2	2	1	2	2	5	2	27	8	Yes	7	42
Urip Sumoharjo (behind finance bld)	Urban farm	38	14	3	2	4	2	3	3	1	6	42	8	Yes	7	14
Borong	Urban farm	40	16	2	2	3	3	3	9	5	3	30	8	Yes	7	18
Baddoka	Urban farm	41	14	8	5	4	3	6	5	0	0	17	6	No	6	21
Baddoka	Urban farm	42	15	7	2	2	3	5	2	0	1	15	7	Yes	6	31
Baddoka	Urban farm	43	13	4	1	2	2	7	2	0	0	11	6	No	6	27
Antang	Urban farm	67	18	8	7	7	7	6	7	0	0	41	6	No	6	18
Antang	Urban farm	68	17	6	3	3	2	2	4	2	0	25	7	No	7	19
Antang	Urban farm	69	19	1	1	3	5	6	1	2	1	32	8	Yes	7	18
Urip Sumoharjo (behind finance bld)	Wetland	37	16	2	1	3	8	5	5	8	1	18	8	Yes	7	20
Teuku Umar Fishing Lake	Wetland	53	16	1	1	2	0	3	1	4	2	28	7	Yes	6	19
Teuku Umar Fishing Lake	Wetland	54	18	1	2	2	1	3	1	5	1	25	8	Yes	7	14
Borong	Wetland	58	10	1	0	1	1	1	2	8	6	19	7	Yes	6	33
Borong	Wetland	59	17	1	1	3	5	4	2	6	1	22	8	Yes	7	22
Minasa Upa	Wetland	60	17	6	4	4	5	2	2	10	0	27	7	No	7	14
Minasa Upa	Wetland	61	12	0	0	1	1	1	1	10	0	11	5	No	5	15
Panakkukang	Wetland	62	14	1	7	5	2	1	1	2	4	19	8	Yes	7	12
Panakkukang	Wetland	63	12	3	2	1	1	8	1	4	6	28	8	Yes	7	32

Note: DV = Domin value